DEC 26 1924

Printed on Thin Paper for Foreign Circulation.

The Engineer.

Established 1856. Registered as a Newspaper.

OFFICE FOR ADVERTISEMENTS & PUBLICATION, 33, NORFOLK ST., STRAND, LONDON, W.C.2.

VOL. CXXXVIII.—No. 3598] LONDON: FRIDAY EVENING, DECEMBER 12, 1924 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

Maintenance Engineer REQUIRED by the GOVERNMENT of the GOLD COAST for Waterworks for two tours of not less than 12 nor more than 18 months' service. Salary £480, rising to £920 a year. Outfit allowance of £60 on first appointment. Free passages and quarters. Liberal leave on full salary. Candidates, aged 24-35, must be Student or Associate Members of the Institution of Civil Engineers, have been trained in the office of a Waterworks Engineer, and/or been in the employ of a Waterworks Company and possess experience in the construction of reinforced concrete tanks.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/13,270. 7741

Bombay, Baroda, and Central INDIA RAILWAY COMPANY.
ELECTRIFICATION OF BOMBAY SUBURBAN LINES.

The Directors are prepared to receive TENDERS for the SUPPLY of the following PLANT required for the equipment of manually operated Traction Sub-stations :—

1. SUB-STATION and TRACK SECTIONING SWITCHGEAR and ACCESSORIES.
2. ROTARY CONVERTER SETS.
3. TRANSFORMERS.

Alternatively for Automatic Sub-stations :—

4. SUB-STATION EQUIPMENTS and TRACK SECTIONING SWITCHGEAR.

Fee for specifications £2 per copy.

Specifications and forms of Tender (which must be submitted in duplicate) may be obtained at this office on and after December 10th, 1924, on payment of the fee for the specification, which payment will not be returned.

Contractors may Tender for any or all of the above sections. Tenders must be sealed and addressed to the undersigned, marked "Tender for Sub-station Switchgear," or as the case may be, and delivered not later than Noon on Tuesday, 24th February, 1925.

The fee should accompany any application by post. Cheques and postal orders should be crossed and made payable to the Bombay, Baroda and Central India Railway Company.

The Directors do not bind themselves to accept the lowest or any Tender.

The Consulting Engineers, to whom applications for any further technical information may be made, are Messrs. Merz and McLellan, 32, Victoria-street, Westminster, S.W. 1.

S. G. S. YOUNG, Secretary.

Offices : The White Mansion, 91, Petty France, Westminster, S.W. 1. 8th December, 1924. 7743

County Borough of Eastbourne. BOROUGH ENGINEER AND SURVEYOR'S DEPARTMENT.

TENDERS are INVITED for the REMOVAL of existing TIDAL FLAPS, &c., in the Valve Chamber, Langney Point, and the SUPPLY and FIXING of NEW TIDAL and SLUICE VALVES.

Plans, specification, and form of Tender may be obtained from, and general conditions of contract seen at, the Borough Engineer's Office, Town Hall, Eastbourne, on and after the 8th December, on payment of a deposit of One Guinea, which will be refunded on receipt of a bona fide Tender and the return of the plans.

Sealed Tenders, endorsed "Valves, Langney Point," to be delivered at the Borough Engineer's office not later than 5th January, 1925.

The Corporation do not bind themselves to accept the lowest or any Tender.

LESLIE ROSEVEARE, M. Inst. C.E., Borough Engineer.

The Town Hall, Eastbourne, December, 1924. 7708

BY ORDER OF THE RECEIVER.
Re BRADBURY and CO., Ltd.
WELLINGTON WORKS, WELLINGTON-STREET, OLDHAM.

For Sale by Private Treaty, the above valuable WORKS, together with the Boiler, Millwrights' Work, Steam, Water and Gas Piping and Sprinkler Installation.

The works, which are centrally situated, are situate up to three prominent streets and within 3 minutes' reach of TWO IMPORTANT RAILWAY STATIONS.

The buildings are substantial in character and can be adapted for many classes of business.

The main entrance is at present in Wellington-street, but a separate entrance to the premises could be made from the Brunswick-street side, which is an important thoroughfare.

NOTE.—It is possible for any purchaser of the works, if so desired, to divide up the premises for letting purposes.

The site contains 5507 square yards or thereabouts, and is subject to a yearly chief rent of £81 12s. 6d.

For further particulars and permission to view apply to ALLEN MELLOR and CO., Auctioneers and Valuers, 21, Queen-street, Oldham (Tel. Nos., 1698 and 1699). 7663

PUBLIC HEALTH ACT, 1875.

Rural District of St. Albans. LONDON COLNEY MAIN DRAINAGE.

The Rural District Council of St. Albans, acting as the Sanitary Authority for the said district, are prepared to receive TENDERS for the MAIN DRAINAGE of London Colney. The work consists of Sewers, Manholes, Outfall Works, Ejector Chambers, Engine-house, &c.

Particulars and specification may be obtained at the offices of the Consulting Engineers, Messrs. Howard Humphreys and Sons, 38, Victoria-street, Westminster, on and from Friday, the 12th of December, 1924, until Friday, the 2nd January, 1925, between the hours of 10 a.m. and 4 p.m., upon payment of a deposit of Three Guineas, which deposit will be returned upon receipt of a bona fide Tender which is not subsequently withdrawn by the contractor.

The successful tenderer will be required to execute a contract deed, the draft of which may be seen at the offices of the Consulting Engineers when the drawings are inspected.

Tenders must be on the official form, each Tender in a sealed envelope marked "Tender for London Colney Main Drainage." Tenders must be accompanied by the general conditions and specification as issued by the Consulting Engineers.

Each Tender must be signed in the handwriting of the tenderer or his authorised agent.

The Council does not bind itself to accept the lowest or any Tender.

Tenders must reach the undersigned by 9 a.m. on Friday, the 16th of January, 1925.

Given under my hand the 8th day of December, 1924.

E. F. W. HEATT, Clerk to the Rural District of St. Albans.

Union Offices, St. Albans, Herts. 7748

The Engineer

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The "Chimney" Conduit of the Grey Friars Monastery.

The Smithfield Club Show.

The Work of W. & R. E. Froude.

Wire-Drawing and Wire-Working Machinery (No. XIX.).

100 Years of British Railways—No. XXIV.

New Waterworks in Guernsey.

Institution of Mechanical Engineers.

Locomotive Superheaters.

A New Rapid-Hardening Cement.

PUBLIC NOTICES

Napsbury Mental Hospital, NAPSBURY, ST. ALBANS.
FOR DISPOSAL.

The Committee of this Hospital have a Manlove-Alliott DISINFECTOR, TWO PRESSURE WASHING MACHINES, TWO POWER BOX MANGLES, a Davey-Paxman VERTICAL STEAM ENGINE, and a QUANTITY of PIPE and STEAM TUBE FITTINGS FOR DISPOSAL. The surplus articles may be seen at any time except Saturdays and Sundays between the hours of 10 and 4.

Detailed lists may be obtained on application to the CLERK and STEWARD, and Offers should be sent not later than 31st December, 1924. 7689

Taf Fechan Water Supply BOARD.
TENDERS FOR STEEL PIPES, VALVES, &c.

The Taf Fechan Water Supply Board are prepared to receive TENDERS for the SUPPLY and DELIVERY at certain railway stations in South Wales of about 5000 TONS of STEEL SOCKET and SPIGOT PIPES of diameters ranging from 37in. to 17in., together with certain CAST IRON PIPES, VALVES and SPECIALS, all of British materials and manufacture. Though lap-welded steel pipes are specified, tenderers are at liberty to offer other makes of steel pipes, but riveted pipes will not be accepted. Drawings may be seen and specification and form of Tender obtained at the offices of Sir Alex. Binnie Son and Deacon, 20, Buckingham-gate, Westminster, S.W. 1, on payment of a cheque for £5 made out to the Taf Fechan Water Supply Board, which amount will be returned on receipt of a bona fide Tender. Sealed Tenders, endorsed "Tender for Steel Pipes, Valves, &c.," should be delivered at my office at or before Noon on Tuesday, the 23rd day of December, 1924. The lowest or any Tender will not necessarily be accepted, nor will any expenses in connection with tendering be defrayed. No Tenders will be considered except from actual manufacturers capable of supplying the pipes at the rate of 600 tons per month, together with a proportionate number of valves and specials.

J. COLENSO JONES, Clerk to the Board.

Board's Offices : 101, High-street, Merthyr Tydfil. 1st December, 1924. 7660

The Guardians of the Poor of the PARISH of LAMBETH hereby invite TENDERS for the PROVISION and INSTALLATION of a MULTITUBULAR HEATER at their Lambeth Hospital.

Specifications, together with form of Tender, may be obtained from this office. Tenders are returnable on or before Tuesday, the 6th January, 1925. The Guardians do not pledge themselves to accept the lowest or any Tender.

By Order, JAMES L. GOLDSPINK, Clerk to the Guardians.

Guardians' Offices : 128, Brook-street, Kennington, S.E. 11. 11th December, 1924. 7759

The Guardians of the Poor of the PARISH of LAMBETH hereby invite TENDERS for the PROVISION and INSTALLATION of an HYDRO EXTRACTOR at their Norwood School.

General description of machine required, together with form of Tender, may be obtained from this office. Tenders are returnable on or before Tuesday, the 6th January, 1925. The Guardians do not pledge themselves to accept the lowest or any Tender.

By Order, JAMES L. GOLDSPINK, Clerk to the Guardians.

Guardians' Offices : 128, Brook-street, Kennington, S.E. 11. 11th December, 1924. 7758

PUBLIC NOTICES

The South Indian Railway Company, Limited, are prepared to receive TENDERS for the supply of :—

45 BOGIE STEEL COVERED GOODS WAGONS.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Wagons," must be left with the undersigned not later than 12 Noon on Friday, the 13th February, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of the specification.

Copies of the drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. Robert White and Partners, of 3, Victoria-street, Westminster, S.W. 1.

A. MUIRHEAD, Managing Director.

91, Petty France, S.W. 1. 10th December, 1924. 7757

County Borough of West Ham. WEST HAM MUNICIPAL COLLEGE, ROMFORD-ROAD, STRATFORD, E. 15.

APPLICATIONS are INVITED for the POST of full-time ASSISTANT TEACHER in the Department of Engineering from candidates with University Degree and works experience. Salary in accordance with the Technical Burnham Scale for the London area, less 5 per cent., and subject to deduction for superannuation. Applicants must be members of a recognised teachers' organisation.

Forms of application may be obtained from the Principal, and should be returned not later than Monday, 5th January, 1925.

GEO. E. HILLEARY, Town Clerk.

Education Department, 95, The Grove, Stratford, E. 15. 3rd December, 1924. 7733

Middlesex County Council. ENGINEER'S AND SURVEYOR'S DEPARTMENT.

REQUIRED AT ONCE, TEMPORARY ENGINEERING ASSISTANT, accustomed to the complete design of Brick and Steel Railway Bridges.

Applications, stating experience and salary required, with copies of not more than three recent testimonials, to be sent to the undersigned not later than Saturday, December 20th, 1924.

A. DRYLAND, County Engineer.

Guildhall, Westminster, S.W. 1. 5th December, 1924. 7734

DIRECTOR OF RESEARCH FOR CHILEAN NITRATE INDUSTRY.

The Association of Producers of NITRATE of SODA in Chile intends to organise a Central Research Department in that country.

A DIRECTOR of RESEARCH, salary £3000 per annum, and TWO SUB-DIRECTORS, salaries £2500 each per annum, are REQUIRED. The appointments will be for three years in the first instance. Chemists, or Chemical Engineers, with first-class scientific training and successful experience in the scientific investigation, design, and operation of large-scale processes and plant, are wanted for these posts. Applicants should be, if possible, between 25 and 45 years of age. No previous knowledge of Spanish is required.

For further particulars apply to THE SECRETARY, THE CHILEAN NITRATE COMMITTEE, Friars House, New Broad-street, London, E.C. 2. 7712

PUBLIC NOTICES

South Staffordshire Water- WORKS COMPANY.
MECHANICAL DEPARTMENT.

APPLICATIONS are INVITED for an experienced MECHANICAL ENGINEERING ASSISTANT. Must be a good Draughtsman and fully conversant with the Design and Construction of large Pumping Units of all types. Applicants having a knowledge of Electricity preferred.

Commencing salary, £275 per annum, which is subject to deductions under the Company's superannuation scheme.

Applications, with copies of three recent testimonials, should state experience, age and when at liberty, and be addressed to the undersigned, endorsed "Mechanical Assistant."

FRED. J. DIXON, M. Inst. C.E., Engineer-in-Chief.

Engineer's Office, 26a, Paradise-street, Birmingham, 3rd December, 1924. 7715

The Municipality of Singapore, STRAITS SETTLEMENTS.
CHIEF ASSISTANT GAS ENGINEER.
ADVERTISEMENT.

The Municipal Commissioners of Singapore REQUIRE a CHIEF ASSISTANT GAS ENGINEER, age about 30-35, of sound constitution, and unmarried. He must have had a good technical education, a regular training as a Gas Engineer, with general all round experience, including Carbonising and Water-gas Plant, both in the design and in the construction of new works and in ordinary maintenance and in distribution.

The appointment will be on agreement for three years with possible extension. The selected candidate must pass a medical examination as to his fitness for service in a tropical climate. A passage will be provided with half salary during the voyage out.

The salary will be 7440 dollars for the first, 7920 dollars for the second, and 8400 dollars for the third year, paid monthly, the value of the dollar being two shillings and fourpence sterling. For the first year the salary would be equal to £366 as above, with an allowance for such transport as may be required when on duty.

Applications, stating age and place of birth, and giving details of education, training, and experience generally, and in carbonising machinery and water-gas plant, and stating when free, accompanied by copies (only) of testimonials, and also personal references, to be lodged with Messrs. C. C. LINDSAY and PEIRCE, MM. Inst. C.E., 180, Hope-street, Glasgow, Agents for the Municipal Commissioners (from whom further information may be obtained), not later than Tuesday, 16th December, 1924. 7709

The Municipality of Singapore, STRAITS SETTLEMENTS.
WATER ENGINEER.
ADVERTISEMENT.

The Municipal Commissioners of Singapore REQUIRE a WATER ENGINEER, age 32-40, on a four years' agreement, with possible extension. Candidates must have had considerable experience, in a responsible capacity, of the design and maintenance of important waterworks, including impounding reservoirs, pumps, slow sand and mechanical filters, service reservoirs, detection of waste and the distribution of water throughout a large town. The selected candidate will be required to control the whole of the Water Department and to advise the Commissioners on all matters regarding the water supply of the city, apart from a large new water scheme now in progress under a Westminster firm of engineers. He must be a Corporate Member of the Institution of Civil Engineers, having responsible experience with a water company or the Water Department of a Public Authority. Administrative experience is an essential of this appointment. The population supplied with water is about 350,000 and the whole supply is impounded and pumped. There is a considerable area of open sand filters, but the filtration capacity is to be greatly extended and mechanical filters are under consideration. Two pumping engines, each of about 8½ million gallons per day, are about to be installed, with boilers and auxiliary plant. There is a salt water pumping and distribution system. The total expenditure of the Water Department in 1923 was about £250,000 and the average daily consumption was nearly 11,000,000 gallons, of which a large portion is waste and must be reduced.

Salary 13,000 dollars for the first, 13,800 dollars for the second, 14,400 dollars for the third, and 15,000 dollars for the fourth year, paid monthly in dollars, the currency of the Colony, the value of the dollar being two shillings and fourpence sterling. The pay of the appointment for the first year at this rate would be £1400, rising to a maximum of about £1600 in 5 years. Such local transport allowance as may from time to time be sanctioned by the Commissioners will be paid. Free passage will be provided with half-pay during the voyage out. The selected candidate must pass a medical examination.

Applications, stating whether married or single, age, and place of birth, and giving details of education, training, and experience, particularly in waterworks, and referring to all the above requirements in detail, accompanied by copies (only) of testimonials, to be lodged with Messrs. C. C. LINDSAY and PEIRCE, MM. Inst. C.E., 180, Hope-street, Glasgow, Agents for the Commissioners, not later than Tuesday, 23rd December, 1924. 7721

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SITUATIONS OPEN

COUNTY OF LONDON ELECTRIC SUPPLY CO., LTD.
"JUNIOR SWITCHBOARD ATTENDANTS."
APPLICANTS for above are THANKED for their letters and advised that the POSITIONS are now FILLED. 7747 A

WANTED, ESTIMATE CLERK (Fully Qualified), used to Wrought Iron Tube Trade.—Apply, stating experience, age, and salary required, to P.O. Box 24, Walsall. 7782 A

WANTED for Ceylon, MECHANICAL ENGINEER of good address and education with knowledge Gas and Oil Engines. Drawing-office experience and practical training. Age 25.—Apply in writing with full particulars to REKLAW, 36, Basinghall-street, London, E.C. 2. P9387 A

WANTED FOR THE FAR EAST, FACTORY SUPERINTENDENT experienced in the manufacture of GYPSUM plaster.—Applications by letter only, stating age, experience, and salary required, to be forwarded, with three copies of testimonials, to W. J. PERKINS, A.M.Inst.C.E., M.I.Mech.E., Consulting Engineer, 26, Victoria-street, Westminster, London, S.W. 1. 7763 A

WANTED, STRUCTURAL ENGINEER. Applicant would work in London and should be competent to design and detail all classes of Reinforced Concrete Work; should be a good draughtsman and must be able to estimate the cost of work. Preference to man with experience of Pile Driving and practical Construction Work. State qualifications, age, and salary required.—Address, 7719, The Engineer Office. 7719 A

ENGINEER.—REPRESENTATIVE WANTED, London, Cranes, Aerial Ropeways, Handling Plant. Chief qualification: the getting of orders. Applications treated in confidence.—Address, stating experience, salary expected, and when free, 7695, The Engineer Office. 7695 A

ENGINEER, with Specialised Water-works experience, REQUIRED to proceed to the Colonies after suitable training, and to be responsible for the preparation of schemes and installation of plant. Knowledge of filtration, water softening and sterilisation desirable, but not essential. Associate membership of Civils or Mechanicals a recommendation. Excellent opportunity for man of enterprise and initiative.—Address, 7744, The Engineer Office. 7744 A

ENGINEERING ASSISTANT REQUIRED, to Set Out and Prepare Plans for Roads and Sewers on housing estate.—State experience, age, and salary required to Box E. A., c/o H. Anderson and Co., 14, King William-street, W.C. 2. 7739 A

INSPECTOR REQUIRED for High-powered Aero-engines; must be fully qualified to examine and report on same in all stages of assembly and especially when stripped down after running tests. Applicants must have been previously employed in a similar capacity and be prepared to qualify for a Ground Engineer's Certificate.—Address, 7735, The Engineer Office. 7735 A

LARGE Firm of Gas Appliance Manufacturers REQUIRE the SERVICES of a YOUNG MAN with technical and practical knowledge to train up for a POSITION of TRUST.—Address, P9911, The Engineer Office. P9911 A

MANAGER REQUIRED for Works Manufacturing Motor Engines for stationary and marine purposes. Must have experience of production methods.—Address, stating age, experience, and salary required, 7748, The Engineer Office. 7748 A

MATERIAL LIST WRITER WANTED IMMEDIATELY by Engineering Firm in N.W. London. Must have had shops and drawing-office experience. Between 25-35 years of age.—Address, stating age, experience, and salary required, 7730, The Engineer Office. 7730 A

TEST ASSISTANTS REQUIRED for the Aero-dynamics Experimental Department of the Royal Aircraft Establishment. Technical training to the standard of a degree in natural science or engineering is essential, and candidates must be willing and medically fit to fly as observers. Other things being equal, preference will be given to ex-Service men. Starting salary about 60s. per week plus cost-of-living bonus, giving a present total of about 95s.—Apply, giving full particulars and quoting A. 43, to the SUPERINTENDENT, R.A.E., South Farnborough, Hants. 7761 A

TEST ASSISTANT, with Technical Training to the standard of B.Sc. degree and works and drawing-office experience, REQUIRED at the Royal Aircraft Establishment, in connection with checking by calculation the strength and aerodynamic characteristics of aeroplanes. Starting salary 60s. per week plus Civil Service bonus, giving a present total of 94s. 11d. p.w. Ex-Service man preferred.—Apply, quoting A. 42, to SUPERINTENDENT, R.A.E., South Farnborough, Hants. 7729 A

VACANCY will Shortly Occur for a SECRETARY in an Engineering Works in the Yorkshire district. The position offers excellent scope, but needs an accurate man who has good experience of both secretarial and general office work, and is accustomed to undertake responsibility. Salary about £300 per annum, with possibility of small bonus.—Address in confidence, giving full details of experience, age, and when at liberty, 7725, The Engineer Office. 7725 A

WORKS MANAGER WANTED. Good All-round man. Must be up to date in latest workshop practice for economical production. Control of men essential. State age, experience, qualifications, and salary.—Address, P9896, The Engineer Office. P9896 A

WANTED for the North Midlands, DRAUGHTSMAN with experience in Steam Winders design and details, preferably with knowledge of Electric Winders. State age, detailed particulars of experience, and salary required.—Address, 7756, The Engineer Office. 7756 A

A COMPETENT DRAUGHTSMAN REQUIRED for a Constructional Engineering Works in the London district. Should be a good mathematician. A man having a knowledge of bridge work preferred.—Address, 7730, The Engineer Office. 7730 A

ASSISTANT ENGINEER-DRAUGHTSMAN REQUIRED for firm of designing Engineers in North of England; both theoretical, shop and drawing-office training essential; experience in Gas Producer and Gasworks Plant an advantage.—Write, stating age, exps., to "E.R.197," c.o. Deacon's Advt. Agency, Leadenhall-street, London, E.C. 7716 A

DRAUGHTSMAN (Engineering) REQUIRED. Experienced in motor lorry work (London).—Address, stating experience and salary required, 7764, The Engineer Office. 7764 A

DRAUGHTSMEN.—Good DRAUGHTSMEN REQUIRED temporarily in London Engineer's Office for Structural and General Railway Work.—Address, stating age, experience, and salary required, 7718, The Engineer Office. 7718 A

DRAUGHTSMEN REQUIRED, Experienced in Printing Press Work.—Write full particulars to R. HOE and CO., Ltd., Borough-road, London, S.E. 1. 7653 A

DRAUGHTSMAN REQUIRED for MACHINE TOOLS. Must be accurate and thoroughly reliable. Reply stating qualifications.—Address, "ALPHA," Wm. Porteous and Co., Advertising Agents, Glasgow. P9907 A

DRAUGHTSMAN REQUIRED, Experienced in design of Steam Turbines and Centrifugal Pumps.—Address, stating age, experience, and salary, 7737, The Engineer Office. 7737 A

SITUATIONS OPEN (continued)

DRAUGHTSMAN REQUIRED for AEROPLANE WORK at the Royal Aircraft Establishment. Candidates must have had good works and technical training, and suitable drawing-office experience, preferably on similar work. Salary about 58s. p.w. plus Civil Service bonus, giving a present total of about 84s. per week.—Apply, quoting A. 41, to SUPERINTENDENT, R.A.E., South Farnborough, Hants. 7762 A

DRAUGHTSMEN WANTED for Steam Turbine Details and Power Station Layouts.—Write, stating age, training, experience, and salary expected, to CHIEF DRAUGHTSMAN, English Electric Co., Ltd., Rugby. 7724 A

DRAUGHTSMAN REQUIRED with Experience in the design of Plant for By-product Recovery, Tar Distillation, Oil Refining, &c.; Woolwich district.—Address, stating age, full particulars of experience, and wages required, in confidence, 7755, The Engineer Office. 7755 A

ESTIMATING MECHANICAL DRAUGHTSMAN, experienced, at weekly rate of £3 14s. 9d., including Civil Service bonus, REQUIRED IMMEDIATELY. Applicants must be over 21 years.—Apply by letter to the COMMANDANT, Experimental Station, Porton, near Salisbury. P9886 A

JIG and TOOL DRAUGHTSMEN REQUIRED at Engineering Works in Erith.—Address, stating full particulars of experience, age, and wages required, 7745, The Engineer Office. 7745 A

REQUIRED, a Good SENIOR MECHANICAL DRAUGHTSMAN, with Plant experience, preferably having knowledge of Cable-making Machinery, London district.—Address, with full details, 7742, The Engineer Office. 7742 A

STEEL WORKS DRAUGHTSMAN REQUIRED for Sheffield District. State age, qualifications, and wages required.—Address, 7753, The Engineer Office. 7753 A

SITUATIONS WANTED

A.M.I.C.E., Railway Locomotive Works, D.O., charge of running sheds, automobile, general and civil experience, fully qualified, theoretically and practically, good organiser, used to control of large staffs, some commercial experience, DESIRES POST, moderate salary.—Address, P9882, The Engineer Office. P9882 B

B.SC., STUD. INST. C.E., 2 Years Shops, Surveying experience, sound knowledge modern business methods and French, excellent refs., DESIRES SITUATION, home or abroad, any capacity. Commencing salary secondary if prospects good.—Address, P9898, The Engineer Office. P9898 B

CRANES, TRANSPORTERS, EXCAVATING, CONVEYING, MATERIALS HANDLING MACHINERY.—SPECIALIST in designing, estimating costs, sales correspondence, production, management, public school man, 20 years' live experience, SEEKS ENGAGEMENT, London preferred. Knowledge French, Spanish.—7, Upper Grove, South Norwood, London. P9852 B

ENGINEER, Electrical and Mechanical, with 20 years' varied experience, including power plants, installation and maintenance, fuel economy, commercial and technical training. Excellent references. Available immediately.—Address, P9891, The Engineer Office. P9891 B

ENGINEER, with 18 Years Modern Production, planning, shop, tool design, D.O., and organising experience, DESIRES APPOINTMENT offering scope; experience aero., automobile, instruments, press work, &c.—Address, P9854, The Engineer Office. P9854 B

ENGINEER WORKS MANAGER DESIRES CHANGE. YOUNG, SUCCESSFUL, WELL EXPERIENCED IN ALL DEPTS., ESTIMATING, COSTING, RATE FIXING, PLANNING, JIG AND TOOL DESIGN, TOOLMAKING, UP-TO-DATE PRODUCTION METHODS, ELEVEN YEARS' MANAGERIAL POSITION, TACTFUL, CAN GET GOOD RESULTS.—Address, P9889, The Engineer Office. P9889 B

ENGINEER (34), Practical, Technical and Commercial training, experienced complete industrial installations, SEEKS POST, D.O., erection, buying.—Address, P9905, The Engineer Office. P9905 B

ENGINEER (Age 38), Mechanical and Electrical, wide experience, home and abroad, REQUIRES RESPONSIBLE POSITION. Traction, works control, productive planning, and factory lay-outs. Disengaged Jan. 1st, 1925. Salary £400-£450.—Address, P9910, The Engineer Office. P9910 B

FOUNDRY, IRON AND BRASS.—A First-class MAN SEEKS POSITION to Take Entire Charge. Used to large output and control of men; excellent organiser, metallurgist. Good references.—Address, P9904, The Engineer Office. P9904 B

IRON, STEEL AND ENGINEERING SALESMAN.—Mr. J. PILKINGTON HUNT, having completed six years' engagement with Messrs. Hall and Pickles, Ltd., is now OPEN to DISCUSS the REPRESENTATION of a high-class FIRM in the Manchester and Lancashire area.—Confidential communications to be addressed c.o. The Engineers' Club, Manchester. P9874 B

MECHANICAL ENGINEER, Age 29, with Electrical knowledge, university training, drawing office, direction a lot of maintenance, 12 years' sound experience. Three years out East as assistant engineer. Home or abroad.—Address, P9893, The Engineer Office. P9893 B

MECHANICAL ENGINEER, with Experience as manager of general engineering works and boiler works, used to control of office, estimating, interviewing, designing, maintenance and repairs, is DESIROUS of OBTAINING SIMILAR ENGAGEMENT.—Address, P9906, The Engineer Office. P9906 B

RESIDENT ENGINEER or CONTRACTOR'S AGENT, POSITION WANTED as; roads, bridges, docks, railways.—Address, P9880, The Engineer Office. P9880 B

YOUNG GENTLEMAN, Age 23, with 5 Years' Shop experience and 3 years assistant to manager of ironfoundry, with machine shop and drawing-office, experienced in dealing with customers and carrying jobs through.—Address, 7728, The Engineer Office. 7728 B

DRAUGHTSMAN (31), Steam and Electric Cranes, hoists, haulages, capstans, winches, winders, design, estimates, details, calculations, excellent references, AT LIBERTY.—Address, P9903, The Engineer Office. P9903 B

ENG. DRAUGHTSMAN (29), Used to Pipe and machinery arrangements, oil, water, steam, &c., DESIRES CHANGE (not necessarily as draughtsman), home or abroad, with prospects.—Address, P9897, The Engineer Office. P9897 B

LADY TRACER SEEKING Better POSITION; used to all classes of work, with six years' exp.; excellent refs.—Address, P9888, The Engineer Office. P9888 B

WORKS MANAGER. Long Experience Bridge and shipbuilding and light constructional work, all departments, DESIRES ENGAGEMENT; free early 1925.—Address offers, P9902, The Engineer Office. P9902 B

EXPORT
To South Africa.
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For continuation of For Sale Advertisements see page 3.

A Seven-Day Journal

French Air Line Extensions.

THE French Under-Secretary of State for Aeronautics has given particulars of the programme of air services which it is intended to carry out in the coming year. The line from Paris to Constantinople will be extended to Angora. There will be a line from Nice to Ajaccio and Tunis, which will constitute the first stage of a service that will eventually be carried as far as India. Barcelona will be connected with Algiers and Tunis with Casablanca. The existing line from Toulouse to Casablanca will be extended to Dakar, whence it is intended to create a service of aeroplanes across the Atlantic to Buenos Ayres. While the Germans propose to employ dirigibles between Spain and South America, the French consider that powerful aeroplanes are preferable for the work, as being less susceptible to weather conditions and of travelling much faster. Machines exhibited at the aviation show just opened in Paris have been specially built for these long distance services.

The Endurance of Battleships.

IT is now evident that the conflicting reports of the experiments against the American battleship Washington which took place towards the end of last month were circulated as a matter of policy. Officials of the Navy Department are observing the utmost secrecy in regard to the tests, which they declare to have been the most important and instructive that have ever taken place. The Washington, they point out, contained all the newest devices for minimising the effect of gunfire and submarine attack. In general design, subdivision and armour protection she was practically a replica of the finest battleships now afloat, so that her behaviour under various forms of attack has produced data of supreme value. Notwithstanding the Navy Department's reticence, the newspapers have published long accounts of the firing and other tests, and since these reports agree on essential points, it is possible to gain a fairly accurate idea of what occurred. On the first day the Washington was shelled by the 14in guns of the battleship Texas. While very few of the shells actually penetrated, their impact seems to have started leaks, for at the close of the firing the target vessel had a list of several degrees. The cannonade was resumed a day later, and this time the belt was perforated repeatedly, while heavy fragments of armour were torn away. Some of the projectiles, it is said, passed clean through the ship. Subsequently, depth charges were exploded in the vicinity of the hull, and aeroplanes were sent up to drop 14in. armour-piercing shell on the deck. The ship, however, still remained afloat, and there is some doubt as to whether she was finally despatched by heavy bombs or gunfire. In any case her stout resistance has obviously disconcerted the enthusiasts for aerial and torpedo warfare, who are now forced to admit that the modern battleship is not quite so vulnerable as they had supposed it to be.

Automatic Sub-Stations.

THE London Underground Railway has just announced that two automatic sub-stations are to be built for the Morden extension of the City Railway, and that contracts have been placed with the Metropolitan-Vickers Electrical Company for the rotary converters, transformers and switchgear. The sub-stations will be erected at Balham and South Wimbledon. The former will accommodate three 1500-kilowatt sets and the latter three 1200-kilowatt sets. The Balham station will operate on the same lines as the Burnt Oak automatic sub-station on the Edgware extension, and will be controlled from South Wimbledon. Prior to the opening of the Edgware extension, all the sub-stations on the London Underground system were of the manually operated type, the Burnt Oak station being the first automatic traction sub-station to be put into operation in this country. During the four months or so it has been at work not a single hitch of any kind has occurred, and the engineers seem to be in every way satisfied with the results. The Balham sub-station will have a good deal larger output than the station at Burnt Oak, which only contains two rotary converters.

Annual Report on U.S. Navy.

THE material deficiencies of the United States Fleet are set forth at length in the annual report of the Naval Secretary. Six of the older battleships are said to need a thorough reconstruction before they can resume their place in the first line. In four ships the boilers are so worn that it has become unsafe to use standard pressure, and the vessels cannot, therefore, maintain their nominal speed. New boilers of the oil-burning type are to be fitted when Congress appropriates the requisite funds. The ships in question are also to be equipped with additional protection against submarine and air attack. Practically every other vessel of the Fleet has been in dockyard hands during the past year, extensive repairs having been carried out in some cases. Capital ships, old and new, which had to be discarded under the Washington Treaty, were first stripped of material and fittings, which are being used to replace worn-out parts in the ships retained. Owing to the closing down of the Hampton Roads submarine base through lack of funds, 27 submarines in service there have been laid up at the Philadelphia yard. The building programme recommended by the Secretary comprises eight 10,000-ton cruisers and six river gunboats. In addition, the Chief of Naval Operations asks for five submarines, two of which are to be minelayers and three of the submersible cruiser type; but these boats are not included in the formal programme to be laid before Congress. Authority is again requested for increasing the range of turret guns in thirteen ships by altering the mountings to permit of higher elevation.

Waterloo Bridge.

THE question as to whether Waterloo Bridge is to be preserved as it was originally designed by Rennie, or whether it is to be rebuilt and widened, is once more in the balance. In an interesting report submitted by the Special Committee on Thames Bridges, which was discussed at the London County Council's meeting on Tuesday last, a recommendation was made that the Council of the Institution of Civil Engineers be asked to express its views as to whether, having regard to the present condition of the bridge, it would be practicable and reasonable to underpin all or some of the piers of the bridge so as to render the structure permanently safe and to enable it to be restored to its original form. This decision was come to as a result of a deputation received by the Committee from the Society for the Protection of Ancient Buildings and the perusal of a scheme put forward by Mr. H. H. Dalrymple Hay, describing on behalf of the Society a method of underpinning the piers of the bridge. The Society maintains the view put forward by Mr. Dalrymple Hay, which is supported by two other well-known engineers, that underpinning would provide a safe, permanent and economical remedy, which might be applied to all the piers of the bridge with the exception of No. 4 and possibly No. 5 pier. On the other hand, the Council's own chief engineer and two other eminent engineers have reported strongly against underpinning. If the Council of the Institution of Civil Engineers accepts the invitation of the London County Council full copies of all reports and correspondence will be furnished for its use. We feel sure that the Institution of Civil Engineers will be willing to render what service it can in a technical matter of such national and public importance. The London County Council is manifestly desirous of preserving the original structure, but even if rebuilding proves to be necessary there would appear to be no reason why the features and form of Rennie's masterly design should not be incorporated in the reconstructed bridge.

New British Beet Sugar Factories.

Two further complete factories for refining British-grown beet sugar are, it is announced, to be begun during the early part of next year at Kidderminster and Spalding. The contract for the machinery, including the steel-framed buildings for the factories, has been placed with Duncan Stewart and Co., Limited, of London-road Ironworks, Glasgow. As far as we can learn, the new establishments will be built on the lines of the factory erected on the Colwick Estate at Nottingham, which was completed by the same firm of engineers during the present year. The machinery is to be capable of handling 1000 tons of beet per day, and of producing white refined sugar, and the estimated cost of each of the works projected will be, it is stated, about £500,000. A pleasing feature of this latest development in the British sugar-growing industry is the statement made that fully 90 per cent. of all the machinery used will be manufactured in this country, and for the most part made at Messrs. Duncan Stewart's own works in Glasgow. The new factories are to be opened in September, 1925, in time for the campaign of that year. The new factories, like the Nottingham factory, will belong to a single company, of which Lord Weir is the chairman and Lord Invernairn, Sir John Baird and Sir Ernest Jardine are directors. The managing director of the company is, we learn, Mr. Talbot-Crosbie, of Mosely, Kidderminster. In addition to the factories mentioned above it is hoped to have one at Ely and one at Ipswich, also ready for the 1925 crop of beet. The British Sugar Beet Society is now engaged in formulating a scheme of technical education in connection with the higher administrative posts in the factories.

A Linking Up Scheme for the Supply of Electricity.

SOME time ago the Paisley Corporation accepted a joint scheme for a bulk electricity supply submitted by the Greenock and Kilmarnock Corporations, now incorporated in the Ayrshire Electricity Board. The Greenock section of this scheme, which will link up the three supplies of Greenock, Paisley and Kilmarnock, has been completed, and on Thursday, December 4th, the wife of the Provost of Greenock switched on the current to Paisley at the Greenock electricity works at Dellingburn. The scheme for the interconnection of the Greenock, Paisley and Kilmarnock power stations is considered to be desirable from the point of view of all-round economy. When the Kilmarnock section of the scheme is completed, it will be possible for the Greenock and Kilmarnock stations to supply Paisley independently or in parallel, and for the stations to interchange load with each other. During periods of light loads, such as week-ends, holiday times, and at night, either of the three stations may be shut down, and economical operation will be secured. Moreover, the interconnection of the stations will tend to make the general supply more reliable. The overhead transmission line from Greenock to Paisley passes close to Kilmalcolm and Bridge of Weir, and terminal towers have been provided at these places in order that the line may be tapped. The Clyde Valley Electrical Power Company, however, has the right to supply these two towns, and any supplies of electricity from Greenock to Kilmalcolm and Bridge of Weir will be in the nature of a bulk supply to the company.

Large Locomotive and Rolling Stock Orders.

AN extensive programme of new locomotive and rolling stock production is to be carried out by the London and North-Eastern Railway during 1925, the total cost of which will, it is stated, involve an expenditure of close upon £6,000,000. About one-sixth of this sum is to be allocated to the building of 221 locomotives for goods traffic, and 74 passenger engines, which are to be constructed, in addition to the series of "Pacific" type express locomotives now going through the shops at Doncaster. Additional sleeping cars of the East Coast articulated type are to be built, and will form part of a carriage-building programme comprising 521 vehicles. It is stated that three new trains are to be provided on the Marylebone–Manchester service, and one on the Marylebone–Bradford service, in addition to which there are to be nine new trains for suburban lines. The cost of carrying out this work will be about £1,189,000, to which must be added £2,300,000 for new goods wagons, which, we understand, will include 200 heavy 30-ton wagons, 1400 covered wagons, and 4000 coal wagons of from 12 to 20 tons capacity. At the present time over 2000 of these wagons have been ordered from wagon builders. Renewal of L.N.E.R. permanent way will account for the expenditure of a further £1,250,000, whilst £250,000 is to be spent on new bridges and £150,000 devoted to the cost of cleaning and painting stations.

The Scapa Flow Salvage Operations.

FROM time to time we have commented upon the excellent and regular progress which has been made by Cox and Danks, Limited, in the raising of the German destroyers which were scuttled at Scapa Flow. The firm is now concentrating its attention upon the six destroyers which have been raised and beached at Mill Bay. At the present time, several of the salved vessels are in process of being pumped out, with a view to preparing them for breaking up. Messrs. Cox and Danks have already broken up one of the destroyers in the shipbreaking works they have established at Mill Bay. Another destroyer is now about to leave for the Firth of Forth, where she will probably be broken up at Thos. Ward and Co.'s shipbreaking yard at Inverkeithing.

Power Alcohol from Sugar Beet.

IN another paragraph on this page we give some particulars of two new sugar refineries which will be built during the coming year, and which will help to extend the beet sugar industry of Great Britain. Allied with this young industry on its agricultural side is the important project of producing cheap power alcohol from the sugar beet, which is fostered by the British Power Alcohol Association. With a view to bringing this subject before the notice of the Government, a deputation from the Association—which body is affiliated to the British Empire Producers' Organisation—recently waited upon the Minister of Agriculture. The deputation explained the advantages of a cheap supply of alcohol for industrial and power purposes, and the benefits which such an industry would confer by stabilising the agricultural life of the country. It was asked whether the proposed subsidy of 19s. 6d. per hundredweight on sugar produced from home-grown beet could not be extended to the sugar content of beets used for the production of power alcohol. Central alcohol factories, it was explained, would be cheaper to build than sugar refineries, and larger quantities of beet would be utilised throughout the year, as the factories would work continuously. The Association aims at establishing such central factories on a co-operative basis, which would enable the farmer supplying the beet to participate in the profits made, and to have a first claim on a portion of the product. An important use of power alcohol would be its use as an alternative motor fuel.

The "Chimney" or "Devil's" Conduit of the Grey Friars Monastery.

THE water supply of the Franciscan Monastery of the Grey Friars, which used to stand in Newgate-street, in the City of London, was obtained from two conduit-heads or well-heads, known respectively as the "White Conduit" and the "Chimney" or "Devil's" conduit. The site of the former was in Chapel-street, a turning out of Lamb's Conduit-street, and of the latter in the garden at the back of the house, No. 20, Queen-square, Bloomsbury, some few hundred yards to the westward. The stones of the "Chimney" conduit were removed between the years 1911–13, in order to make room for an extension of the Imperial Hotel, Russell-square. The removal was effected by Messrs. James Smith and Son, builders, of South Norwood, upon the instructions and at the expense of the Duke of Bedford, each stone being carefully marked and its position shown on drawings specially prepared, so that the "Conduit" could be rebuilt. After their removal they were stacked in the builders' yard at South Norwood, and there they remained until it recently came to the knowledge of the General Purposes Committee of the Metropolitan Water Board that unless steps were taken to prevent it, they were in danger of being broken up. The Committee accordingly arranged to have them transported to the New River yard, at the rear of the Board's head office building in Rosebery-avenue. The proposal now is that they should be permanently preserved by re-assembling them at the head office. Mr. Dove, the vice-chairman of the Board, has offered to lend one of his own workmen, who is specially skilled in the restoration and repair of mediæval stonework, and it is suggested by the Committee that the work of rebuilding should be done by the Board's own workpeople acting under the direction of this expert. It is estimated that the re-building and restoration can be effected for the sum of about £400.

An interesting note on the subject of old conduits in Bloomsbury and Pentonville has been prepared by Mr. G. P. Warner Terry, the Board's assistant clerk, and a copy of it has been courteously placed at our disposal. This document, which itself contains a large number of interesting data, also makes reference to several publications that give information concerning these conduit-heads, and among those publications may be cited a communication entitled "Recent Discoveries of Medieval Remains in London," which was made to the Society of Antiquaries of London by Dr. Philip Norman in December, 1915, and was published in "Archæologia," Vol. LXVII. From that paper Mr. Warner Terry gives several extracts. Dr. Norman, in reply to our request to be permitted to reproduce certain illustrations which accompanied that communication and to quote from the text, courteously, with the concurrence of the Council of the Society, gave his consent, and we are indebted to that source for the particulars contained in what follows.

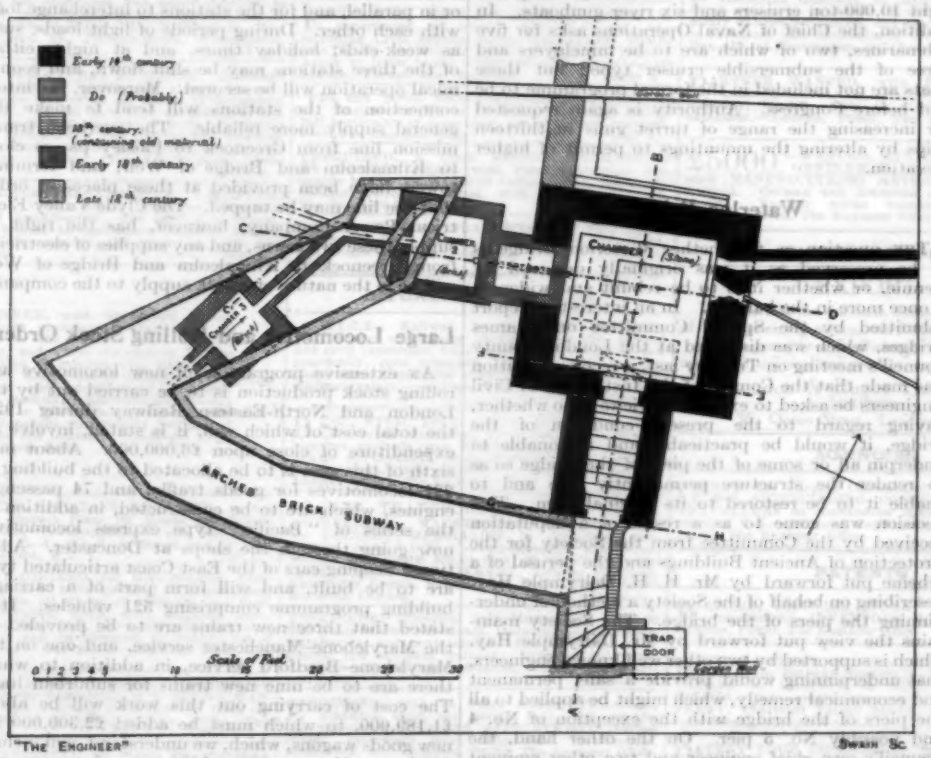


FIG. 1—PLAN OF THE "CHIMNEY" OR "DEVIL'S" CONDUIT

It appears that the original water system of the Monastery ended at what, in the seventeenth century, came to be called the "White Conduit," of which there were, at the date of Dr. Norman's communication, still remains under a room behind a house in Chapel-street, Lamb's Conduit-street. The works, which were built between 1255 and 1258, were very soon found to be inadequate for their intended purpose, and about fifty years later there was an extension to a point, then in the open country, about a quarter of a mile further west, which, latterly, was in a garden at the back of No. 20, Queen-square, Bloomsbury. The later works—the "Chimney" Conduit-head—consisted of an underground reservoir, which was approached by steps down an arched passage, the upper portion of which was originally above ground. In this reservoir water, obtained from springs in the neighbourhood, was stored, and flowed thence through a leaden pipe to the Monastery.

Christ's Hospital School was founded in 1533 by Edward VI. on the site of the Monastery, and at first, apparently, it obtained its supply of water wholly from the "White" and "Chimney" conduits, and it continued until the earlier part of the eighteenth century to receive water from those sources, though before 1665 it also obtained supplies from the New River Company. Rocque's map of 1745–6 shows the site of the "Chimney" conduit in a small square, open on the south to Brunswick-square, now Queen-square-place. Some years afterwards the conduit head, then fallen into disuse, was merged in the garden of No. 20, Queen-square.

When the work of demolition above referred to was begun in July, 1911, Dr. Norman, who had previously both by himself and in conjunction with Mr. Ernest A. Mann investigated, and read papers on, the Conduit, took the opportunity of making a detailed examination. He states that the only indication above ground of what was beneath was a flat stone about 2ft. 6in. square, with a circular wrought iron grating which covered the ventilating shaft of the reservoir. Above the reservoir there was a depth of 13ft. or more of made earth before the natural soil, which was clay with, for the most part, a thin layer of gravelly loam above it, was reached. The reservoir was nearly full of water, which, it was afterwards discovered, percolated, not through any pipe, but chiefly under the masonry, and was, with difficulty, got out by pumping.

The accompanying drawings—Figs. 1 and 2 and the half-tone engravings, which are reproductions of those used to illustrate Dr. Norman's communication from which we are quoting—will serve to make clear the following description, which we give in the author's actual words:—

"Descending through the trap-door in the garden, and then by a modern stair, one reached a landing, with an eighteenth-century brick archway on the left hand, and in front the entrance to the medieval portion. This was the first of a series of stone arches—see Figs. 3 and 4—with vaulting above, which

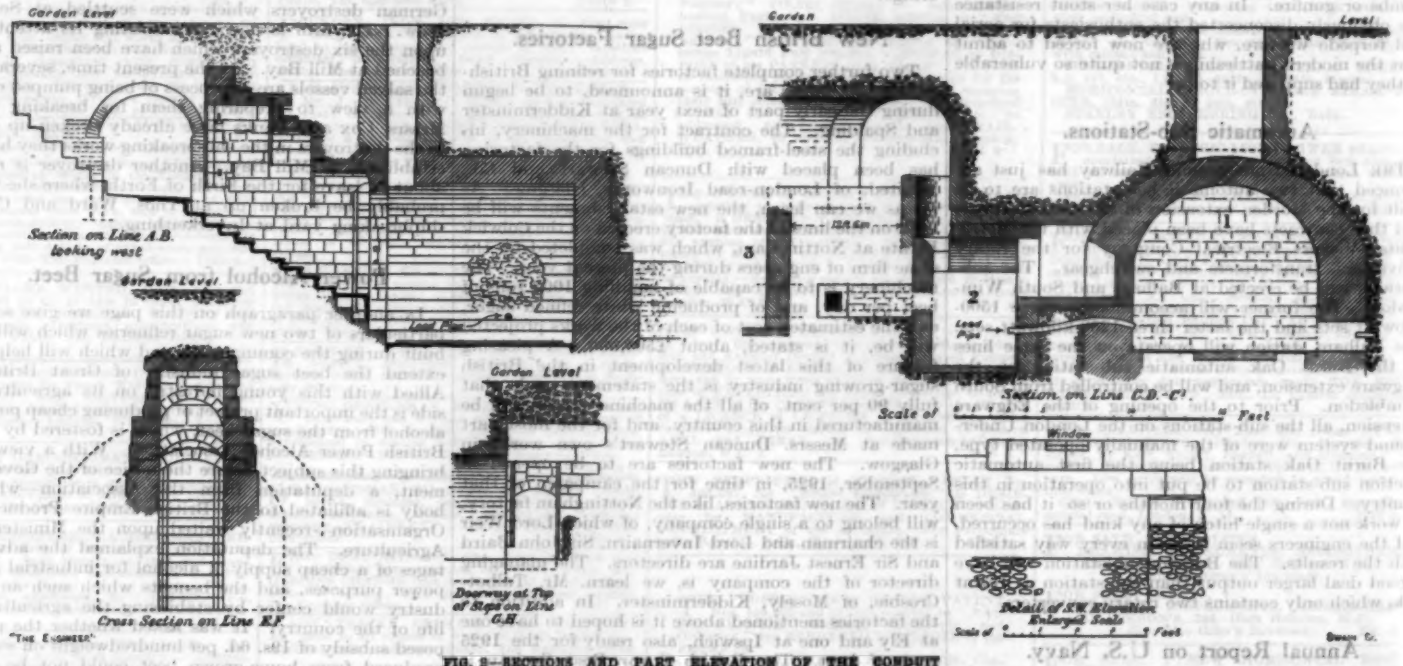


FIG. 2—SECTIONS AND PART ELEVATION OF THE CONDUIT

covered steps leading down to the reservoir. The jambs of the doorway were original; inside they projected, forming a rebate for a door, two iron door-hooks still remaining. A flat lintel, apparently of Purbeck, had replaced the former arch, of which, however, there was evidence. A very large stone had been built in over the lintel—see Fig. 3. . . . The two succeeding arches were segmental and had not been tampered with—see Fig. 4. The steps to the reservoir were but slightly worn, having been

renewed at some unknown period. They were then made less steep, and a little platform of the width of two steps was formed at the edge of the water; but evidence of earlier steps was found, the last four being *in situ* beneath the later ones—see Fig. 5, page 670. The jambs of the last archway were carried down as low as the top of the last original step, the base of which was on the floor of the reservoir. These also had a rebate for a door opening inwards, with two iron door-hooks still remaining. Below was a hook for a former door, in use doubtless before the steps were rearranged.

"The stone reservoir—see Figs. 6 and 7—was of fine ashlar work inside; on some of the stones tool marks were distinctly visible. It had a barrel vault which ran north and south.* With slight deviations it was in plan a square of about 10ft. 6in. In the seventeenth and early eighteenth century it was generally called the chimney conduit, on account of a shaft or chimney rising from the vault at its southern end, against the entrance arch just referred to. This chimney, where it joined the vault, was 3ft. in length from east to west, and 1ft. 5in. broad, becoming square above. The base, where it sprang from the vaulting, was of fine stonework, having evidently existed from the beginning. The upper part of brick, dating from the seventeenth or early eighteenth century, passed through an accumulation of made earth. At the modern garden level it was covered by a stone with a grating as already mentioned. The vaulting of the reservoir was of the same character as the masonry of the walls, the stones being carefully shaped and laid with narrow joints. The height inside, to the crown of the vaulting, was 9ft., and the floor was 18ft. below the garden level. It was composed entirely of red paving tiles a foot square, but had let into it, near the north end, a flagstone 4ft. 6in. long by 3ft. There was a stone edge round the tiles mostly about a foot wide. The greater part of it was an inch or two lower than the tiled pavement, forming what looked like a narrow channel; at the north end, however, near the west, they were on a level. This stone edging was rather decayed, so perhaps the depression was caused by its being water worn.

"On the west side, 4ft. from the north wall and about 2ft. above the floor, a 3in. lead pipe, with a lapped joint above, projected into the reservoir. It was plugged with wood and was not an original opening as the ashlar stones had been broken to admit it. The original wall of the tank above had also been broken for a space of 3ft. or 4ft. and filled up with brick and stone rubble.

"In the east wall, close to the north end, there was an oval—nearly round—aperture 6½in. wide, the lower part being if anything below the floor level, which sloped down a little at this corner. Above was a hole broken in the wall at a later period. Quite close to it, farther south, was a large and irregular opening where stones had been broken away at a somewhat higher level"—see Fig. 7.

With regard to the outside of the most ancient portion of the building, Dr. Norman explains that the walls of the passage were composed of fine fishlar work which, when he examined it, was mostly in good condition, and which must have been above the medieval ground level. They had rubble foundations and at a height of one row of stones on each side was a chamfered plinth. The walls of the reservoir were, he states, considerably thicker than those of the passage. Its ashlar vaulting was covered by rubble masonry, thinnest at the crown. The whole, or almost the whole of it, must have been below ground. On the west side near the north end on the second course of stones above the plinth, and immediately opposite to the ventilating shaft, the sill of a window, or opening of some kind, was found—see Fig. 8. Its length was, approximately, 1ft. 7in. There was no indication of a similar opening on the other side.

The north wall of the reservoir was thickest at the bottom and diminished externally by stages or steps. There was a stone wall prolonging the western wall of the reservoir, of substance and construction similar to the remainder except that it had no ashlar work. It ran north, even beyond the brick garden wall, a fact that could be verified because the latter was under-pinned during the excavation. Under this ancient wall—it was probably of early fourteenth century construction—a deep drain ran east and west.

Discussing the apertures in the east wall of the reservoir Dr. Norman says:—"... the oval orifice near the north-east corner soon merged in a square stone channel, traced as far as the wall of the house, and pointing towards the roadway before the gates of the Foundling Hospital. It contained no pipe, but was half full of a very fine sediment. There was a slight fall eastward. Was it merely a drain used at intervals, when the reservoir required cleaning? It would have emptied this completely, and the orifice would have been of convenient form for the insertion of a plug. In the irregular opening about a couple of feet above it—already referred to—traces were found of a leaden pipe. With regard to this no further information is forthcoming; it was clearly not part of the original structure. The more southern aperture in the east wall communicated with a leaden pipe, the end of which was still in the wall; a joint 6ft. or 7ft. to the east had on it the letters WA and date 1578. Where it entered the reservoir, this pipe was contained in a blocked or engaged arch. It was traced east as far as the southern corner of the house, and pointed almost directly to the 'White Conduit.' Although at the time of the demolition its fall in an eastern direction seems to have been hardly perceptible, it must have been an outlet, and in all probability its line indicates that of the original connection with the Grey Friars water system. As this outlet was a little above the floor of the reservoir, solid matter carried in from the springs would have settled to some extent, and its removal from time to time would have been necessary. The Queen-square Conduit-head, however, like other well-known chambers of the kind, was not a mere settling tank but a place of storage for water flowing in from springs in the neighbourhood, that there might be no sudden failure of supply, and that it might be delivered evenly by gravitation to the convent."

Dr. Norman then goes on to explain that in a plan of the Christ's Hospital water system as it was in 1676, the position "of the severall wells and springs arising about this Conduite Head" purports to be shown. They are all connected, and are six in number—four on the west, one on the north, and one on the east—none of them being very near the reservoir. There was no indication of an outlet or inlet for water anywhere except those in the eastern wall just described, and the breaks in the west wall, one admitting the leaden pipe which survived till the end, evidently a late insertion, and the large break above it, which had been filled up with stone and brick. "We are, I think," comments Dr. Norman, "justified in believing that the stone conduit-head was at first supplied with water entering it through a western aperture, but with regard to the original form of the inlet, or possibly inlets, there is no evidence. The material of this ancient building was chiefly Kentish rag, but on his plan Mr. Quirke, of the London County Council, describes the ashlar work inside the reservoir as of Reigate firestone."

In addition to the original structure, there were some other chambers, &c., which Dr. Norman proceeds to describe. On excavating immediately to the west of the inlet pipe on the west side of the reservoir, it was, he says, found that, after passing through the wall of the reservoir and through a short brick passage filled up with clay, at a distance of only about 6ft., the pipe, slightly rising, entered a brick chamber, which was in plan approximately a square of 5ft., with a barrel vault running east and west, its crown being 12ft. below modern ground level. It went down to a considerable depth, about 20ft. below the modern ground level, or 2ft. lower than the floor of the stone reservoir. It had a brick floor, highest in the middle, and a few relics of no great age were found, including a George I. half-penny and fragments of eighteenth century stoneware. High up in the east wall of this chamber was a blocked opening about 2ft. 4in. wide; at the west end, on approximately the same level, were indications of a similar blocked opening, both above the line of the pipe. The brickwork generally had the appearance of belonging to the seventeenth or early eighteenth century. At the west end a large hole was broken in the crown of the vaulting, and it was through that hole that the water in this brick tank could be seen from the later brick passage above, the arched entrance of which, close to the ancient doorway of the steps leading down to the stone

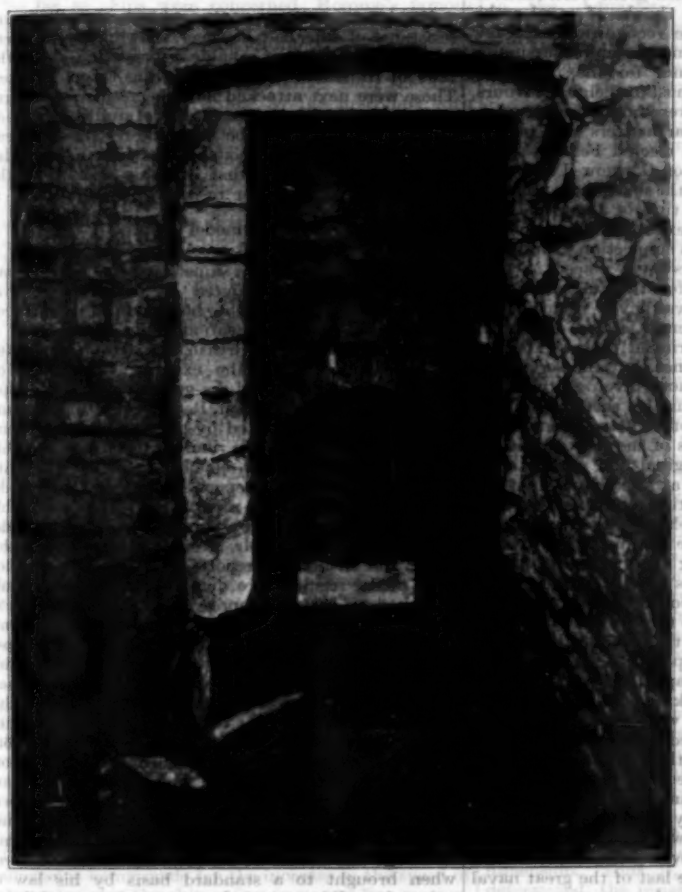


FIG. 3—ENTRANCE TO STAIRCASE LEADING DOWN TO THE RESERVOIR

FIG. 4—AN ARCH LEADING DOWN TO THE RESERVOIR

* The author explains that the points of the compass are used approximately. Actually, the building stood north-west by south-east.

reservoir, was mentioned earlier in this article. On the west side of this brick chamber, about 4ft. above its floor level, there was a brick channel, which, at a distance of 4ft. to 5ft. towards the west, bifurcated, the more northern branch soon coming to an end, as after a short distance it had been destroyed. That to the south-west was found to be connected with a smaller brick chamber, the internal measurements of which were 4ft. by 3ft. 5in. This tank was built on a mortised timber frame. It had no brick floor and no roofing was found. Its base was somewhat less than 3ft. above the floor of the larger brick chamber. The walls were about 5ft. high. A brick channel entered it from the south-west, on the same line as that connecting it with the brick chamber first described. Further to the south-west other brick channels were found branching off in various directions. None of the channels contained any lead piping. Remains of another brick chamber were found further west, but of it there is no precise description available.

The exact use of these brick chambers and of the later archway and brickwork above it remains, and is probably destined to remain, obscure. It is possible that they may have been in the nature of protective works carried out by Christ's Hospital in or shortly after the year 1710, as it is known that some such works were decided upon and effected at that period. Commenting on the matter, Dr. Norman says:—"As to the brick chamber close to the stone reservoir, connected with it by a lead pipe, and communicating through the hole in its roof with the upper passage, there are two conflicting theories. Was it built to protect a spring, or was it in the nature of a settling tank? The main objection to its being the latter is, apparently, that it would be difficult to clean out. Indeed, if the barrel vault were complete, there would be no normal means of access to it. But although the hole in the west part of the roof was latterly irregular, suggesting that it was broken some time after the construction of the chamber, perhaps when the upper brick passage was made, this may have been an enlargement, and there may have been an aperture from the beginning. Besides, . . . a blocked opening was found at each end. The fact that it was enclosed, not only by brick walls, but by a brick floor, makes one hesitate to believe that it was built to protect a spring, and none is marked at this point on the plan of 1676, though water from springs undoubtedly flowed into it from the west through the brick channel with which the other chambers were connected. After all, however, what is most important is the medieval stone conduit-head . . ."

At the time of making his communication to the Society of Antiquaries, Dr. Norman evidently considered the demolition of the structure equivalent to its destruction. Nor did he anticipate its reconstruction. "For although," he remarks, "the stones have been carefully kept and numbered, there seems at present small likelihood of its being erected elsewhere. Besides, almost all the interest of a relic of this kind is lost when it ceases to be on its original site." Nevertheless, we think that the proposal of the Water Board is worthy of full commendation, and feel certain that in its re-erected form the "Chimney" or "Devil's" (the reason of the second name is not exactly known) will form a most interesting souvenir of the Middle Ages.

There is much more of interest in connection with this and similar sources of water supply which have been made available by the researches of Mr. G. P. Warner Terry and of Mr. C. L. Kingsford, the able secretary of the Society of Antiquaries of London, but, unfortunately, we cannot spare space to review it.

The Work of W. and R. E. Froude.

By A. W. JOHNS, C.B.E., R.C.N.C., M.I.N.A.

No. I.

The death of Mr. R. E. Froude on March 19th last brought to a close an interesting and highly important chapter in the development of the science of naval architecture. It marked also the completion of nearly seventy years of patient investigation and increasing and laborious experiment by father and son on the phenomena attending all the phases of a ship's motion. From the practical point of view the first twenty years were not nearly so important as the remainder, although there is little doubt this earlier period was in a great degree a valuable preparation for the later. It was just fifty years ago that Mr. Froude at the meetings of the Institution of Naval Architects described his experiments with H.M.S. Greyhound, and later in the same year he presented to the British Association a complete account of his experiments on the surface friction of planks of various lengths and types of surface moving through water. Both papers are of classical importance in the problem of ship resistance, for it is almost wholly on their results that the present method of computing ship resistance is based. The great improvement in ship propulsion during the past half century is in a great measure due to those two investigations.

Father and son were both trained in the profession of civil engineering, and although taken in its broadest sense, this includes naval architecture, yet their earliest technical experience was concerned more with the problems of transportation by land than by sea. It was indeed fortunate that circumstances permitted Mr. W. Froude to investigate at first theoretically and later experimentally, the laws of resistance appertaining to the passage of bodies through water, a labour which his son extended and successfully completed. At the present time, there is little in the problems of a ship's motions, complicated as they can be, which is not fully understood, and for this we are almost wholly indebted to the investigations and deductions of the two Froudes. The human race has been greatly benefited thereby, for the results of their work have very sensibly reduced the cost and at the same time increased the speed of sea transport, and brought the nations of the world into relatively closer proximity. To the British nation, so dependent for its existence on sea transport and power, the value of their work is incalculable.

There are several other instances which might be quoted in which noted improvements have been effected in certain branches of human activity by those whose earlier experience had been in an entirely different direction. The great improvements introduced by Armstrong, the Newcastle solicitor, in the applications of hydraulics, and later in the design, construction and operations of guns and mountings, will at once occur to the minds of many engineers. But whilst the erstwhile solicitor amassed a considerable fortune and was awarded a peerage for his inventions, the Froudes for their great work received little more than the grateful thanks of naval architects and engineers, and the recognition of a few learned bodies. Both were modest and unassuming men, seeking neither fame nor fortune; pursuing their work to the best and utmost of their endeavours, and fully satisfied that they were improving the state of knowledge on the particular matters they took in hand. Father and son were elected Fellows of the Royal Society and LL.D.'s of Glasgow University, but it is curious in the case of the son that he preferred not to be addressed by the title of Doctor.

Practically the whole of the experimental work of the two Froudes was carried out in connection with British warships. Vessels and crews were placed at their disposal by the Admiralty for the full-scale tests, and professional assistance was given them for the investigation of the experimental results, both from ships and models. The experiment tank at Torquay was built at Admiralty expense, but the services of Mr. W. Froude were throughout given gratuitously. It is to the credit of the Admiralty that they offered no objection, but, on the other hand, encouraged the publication of the reports of the most important experiments. A mass of original and authentic information was thus placed at the disposal of the naval architects of the maritime countries, and the qualities of all types of vessels, war and mercantile, soon began to improve. The leading Naval Powers and many of the shipbuilding firms have erected and equipped model tanks on lines exactly similar to that erected at Torquay in accordance with Mr. W. Froude's designs, a tribute to the success and a proof of the general acceptance of the methods of investigation introduced and developed by him and his son. The intricate machines and apparatus necessary for forming the models and making and recording the results of the experiments, were entirely designed by Mr. W. Froude, who proved himself a most expert mechanical engineer. Up to the present time, five of these tanks have been erected in this country, the most recent being the William Froude Tank at the National Physical Laboratory, erected by the generosity of Sir Alfred Yarrow. Strangely enough, France, the first nation to develop the scientific side of naval architecture, was the last of the great naval Powers to adopt the Froude tank.

Early Investigation of Rolling.

After these introductory remarks, it becomes necessary to consider more in detail the lines on which this important work was initiated and developed. Mr. William Froude was born in 1810, the second of the three sons of the Archdeacon of Totnes. The elder brother, Hurrell, was a brilliant scholar and tutor at Oxford, who died at a comparatively early age, whilst the younger was James Anthony, the historian. William proceeded to Oxford, was placed under his brother, and in due course left the University having secured honours in mathematics, a qualification which proved extremely useful. He adopted civil engineering as a profession, and later became an assistant of Brunel. In 1846, for domestic reasons, he retired from professional work and devoted his time to theoretical and experimental investigations. In 1855 he was requested by Brunel to examine some problems which had arisen in connection with the launch of the Great Eastern, and in the following year he was engaged in the consideration of the phenomena attending the rolling of ships, then a subject on which little had been attempted. He investigated this matter very thoroughly, and as a result presented a paper on the subject to the Institution of Naval Architects at their second annual meeting in 1861. This was followed by others in 1862, 1863, 1865, 1873 and 1875 at the same Institution, in which the various phases of this rather difficult subject were clearly and successfully dealt with. For the purpose of these investigations, it was necessary to develop the trochoidal theory of deep-sea waves—a task which Mr. Froude successfully concluded. His views and deductions were endorsed and accepted in the discussions which followed the readings of the papers. That of 1875 explained his method of graphic integration, by which the rolling of a ship amongst waves of given dimensions and period can be geometrically determined when the resisting moment has been ascertained by experiment on model or ship. By permission of the Admiralty, rolling tests were made on several warships, the results analysed by Mr. Froude, and a clear idea of the forces in operation deduced by him. For these trials he devised an apparatus by which both the angle of roll and the wave slope were automatically registered, an instrument which is still used in similar tests. In addition to the papers presented to the Institution of Naval Architects, he contributed several articles on the same subject to *Naval Science*, a quarterly edited by Sir Edward Reed. The eminent French naval architect, Monsieur Bertin, also wrote some articles for the same publication, in which Froude's deductions were criticised and alternatives suggested. Froude, however, successfully met his critic's objections and proved his own views on the matter were correct. His experience of rolling experiments on ships led him to advocate the fitting of bilge keels to diminish the angle of roll, for he had found by experiments on the Greyhound before and after bilge keels were fitted, that the rolling was very sensibly diminished by their addition.

Resistance.

His investigations on the subject of rolling and resistance of ships had, however, shown him that there was a serious lack of reliable information as to the laws of resistance of bodies moving through water. These were next attacked and theoretical considerations led him to enunciate the law of similitude, which expresses the relations between the resistance, speed and dimensions of a model and those of a similar ship. This law states that if a ship is L times the length of its model, her resistance at a speed V is L^3 the resistance of the model at speed $\frac{V}{\sqrt{L}}$.

Unknown to Froude the same law of similitude had been previously enunciated by a French naval constructor, M. Reech, who, however, did not proceed to an experimental verification.

A committee of the British Association appointed in 1868 to consider the existing knowledge on stability, propulsion and sea-going qualities of ships, included Merrifield, Galton, Rankine and Froude, and in 1869 its report, drafted by the first named, recommended that to obtain more knowledge on ship resistance, experiments should be carried out with actual vessels. The report indicated that model results were generally mistrusted, and presumably for that reason the committee made no recommendation as to their use. Mr. Froude dissented from this view, and in a short report gave it as his opinion that model results were of practical use, and could be relied on as truly representing the resistances of ships to which the models were similar; experiments with them were much less expensive than with ships; the results were free from the effects of wind, tide and seas; and the forms were easily altered or new forms made to ascertain which gave the best results. He mentioned that in 1867 he had experimented with two sets each of three similar models, 3ft., 6ft. and 12ft. long, towed at the end of a 10ft. boom standing transversely from the bow of a steam launch. One set of three was of the wave line form suggested and built by Scott Russell to give minimum resistance, and the other had bluff bows and sterns. Although the curves of resistance for a set of three when brought to a standard basis by his law of comparison did not entirely agree, yet they exhibited the same marked characteristics throughout for each set, and the bluff ended form had appreciably less resistance at the higher speeds than the wave line form.

Some fifty years before this Colonel Beaufoy—the first British experimenter on resistance—had suggested that model experiments would prove of great value in improving the form of warships and would cost little, "no more than the mainmast of a ship." The suggestion was not adopted by the Admiralty, and it is not even clear that it came before the Navy Board for consideration. If it did, there was perhaps some excuse for its rejection, for the motion of a sailing ship involved both an ahead and a leeway velocity, and she was heeled to a varying amount by the wind pressure on her sails. These conditions were difficult to reproduce in a model towed in a dock, as in Beaufoy's experiments, and there was no certainty the best form discovered by Beaufoy's method would retain its superiority when it had the motion and heel referred to. But in 1868 the steamship was rapidly replacing the sailer, and its purely ahead and upright motion was easily reproduced in a model.

Sometime in 1867 or 1868 Sir Edward Reed, then Chief Constructor of the Navy, visited Torquay, witnessed some of Mr. Froude's experiments and, being impressed thereby, suggested to him that he should address a letter to the Admiralty expressing his willingness to conduct experiments on the resistance of ships. This advice was followed, and the offer was accepted, although there was a considerable doubt in the minds of the higher authorities as to the

practical utility of Mr. Froude's model experiments, a fact which prompted Reed to suggest the course to be taken by Mr. Froude. Sir Spencer Robinson, who was at this time controller, frankly admitted at the Institution of Naval Architects in 1877, that he had been taught to distrust model results, and was glad to admit that Mr. Froude's work had completely changed his views. Sir Nathaniel Barnaby, who succeeded Reed in 1870, has also stated that for several years it was difficult to persuade the Admiralty authorities to vote the small amount of money which was required for the expenses of the Torquay establishment, and that it was only secured by very rosy reports by the technical officers. As a result of the acceptance of Mr. Froude's offer by the Admiralty, and his further proposal for a model tank, the latter was erected at Chelston Cross, Torquay, to his designs, and in 1871 was ready for work.

Romme and Beaufoy's Experiment.

It is instructive at this stage to examine the state of knowledge on the resistance of ships then existing, and the methods employed for determining their engine powers. The variation of resistance with the square of the speed was generally accepted. Sir William Petty had expressed this relation in a paper before the Royal Society in 1674, and had probably based his conclusion on experimental evidence. Numerous experiments since his time had confirmed it, and also shown the resistance of a solid increased directly with the sectional area. So far as ships were concerned, Romme's famous experiment in 1784 indicated that the immersed area of midship section was the all-important factor. He constructed two models, one of the *Illustre* on a scale of one-twelfth, and the other with the same midship section and profile as the first, but with straight lines joining stem and stern to the boundary of the midship section. Tried at three different draughts and at various speeds, both models had the same resistances. The models were then cut in two at the midship sections and the fore ends interchanged. Tried again at the three previous draughts and the same speeds the resistances were found to be as at first. A committee of three highly qualified scientists appointed by the Academy of Sciences witnessed the experiments, examined the results, and confirmed Romme's conclusion that the resistance depended only on the immersed midship area and was independent of the form at the ends, so long as the lines were of a regular and fair curvature. This and the variation of resistance with speed formed the basis of the formula for power—I.H.P. varies as $A V^3$—the connecting factor being the Admiralty midship section coefficient $\left(= \frac{A V^3}{\text{I.H.P.}}\right)$.

Beaufoy's experiments on surface friction had shown this type of resistance varied with the area of the wetted surface and also at a rate slightly less than the square of the speed. Errors of experiment would, it was thought, explain this latter difference. It had been stated that Fulton had used Beaufoy's results with success in designing his steamboats. The wetted surfaces of similar ships were proportional to the two-thirds power of their displacements, and it was concluded that the error would not be great by assuming this to hold for dissimilar vessels. Hence the origin of the Admiralty displacement coefficient $\left(\frac{D^{\frac{2}{3}} V^3}{\text{I.H.P.}}\right)$.

Professor Rankine had later suggested another formula which expressed the resistance in terms of the square of the speed and the "augmented surface." The latter was greater than the wetted surface, an allowance being made for the increase in the speed of the water past the ship owing to stream line motion. Very little use appears to have been made of this formula, and the Admiralty coefficients retained their place as the principal determinants of resistance and power.

Work of the Admiralty.

The technical officers at the Admiralty had tabulated in great detail the trial results of all screw ships of the Navy, and published them at intervals for general information, the final one appearing in 1874. The tables, besides giving full details of the ships, engines and propellers, included values of the two Admiralty coefficients for every trial. These values formed the data upon which the powers of engines for new designs of given displacement and speed had to be based. The choice for a naval architect was very wide and uncertain, for the values of the coefficients—as from later knowledge would be expected—varied considerably between individual ships and at different speeds in the same vessel. Small changes in a vessel had a disproportionate effect on the coefficients. In one ship the addition of a false bow increased the length from 200ft. to 218ft., and the displacement from 1080 to 1160, and yet for the same power the speed was raised from 11¼ to 12¼ knots, and the values of the two coefficients from 334 and 126 to 448 and 173. A second ship had her stern lines fined, and for the same power the speed increased from 8.1 to 9.5 knots and the coefficients from 264 and 94 to 404 and 144. Another set of engines placed in the same vessel gave a speed of 8 knots for about half the previous power, and the coefficients became 480 and 170, or nearly double their first values. The tables were full of such apparently inconsistent results, and it was extremely difficult to choose a satisfactory one.

One serious defect of such a method was the impossibility of differentiating between the performance of the hull and that of the engines and propellers. An indifferent result, indicated by a low value of the coefficients, might arise from a bad form of hull or an inefficient engine and screw or both. The acceptance and belief in the midship area coefficient had also a pernicious effect on design, for to secure the smallest power for a given speed, the immersed midship area was made as small as possible. The prismatic coefficients—then an undefined quantity—of warships built previous to the experiments of Mr. Froude were, therefore, large, sometimes approaching .80, a value far beyond that now commonly employed. The adoption of the minimum midship area had, in fact, the opposite result to that which was intended.

It is not at all surprising that Sir Edward Reed, faced with an accumulation of such varying, inconsistent and unexplainable results as those which have been referred to, should welcome and encourage the test of any other method which promised more reliable information for the important purpose for which it was required. In 1870 Mr. W. Froude was appointed a member of the Committee of Designs, which examined the designs of the Devastation and Cyclops and made certain recommendations to the Admiralty in 1871. Such a position strengthened his influence in the direction of pressing forward his proposals, and rendered it easier to carry out any necessary experiments so far as full-sized ships were concerned. It was, in fact, on the recommendation of this committee that the towing trials on the Greyhound were made and that rolling experiments were carried out on her and other ships.

Surface Resistance.

Between 1871 and 1874 Mr. Froude was engaged on several important experimental investigations, one being on surface friction, the second the full scale tests on Greyhound, and the third on the Ramus proposal for stepped bottoms on ships; neither the second nor third could be completed until the results of the first were available. In the surface friction experiments planks varying in length from 1½ft. to 50ft. and with their surfaces coated in turn with materials of different roughness were used, the range of speed being from 100ft. to 800ft. per minute. The results showed that with the rougher surfaces the resistance varied as the second power of the speed for all lengths, and although this held for the shortest smooth surfaced planks, for the longer the index of the speed was less and for the 50ft. length was 1.83. The mean resistance per square foot of surface at constant speed decreased as the length increased, and for the 50ft. lengths was 60 to 65 per cent. of that for the 2ft. length. The variation of resistance with speed and length being determined within the limits imposed by the tank and apparatus, it was not difficult to approximate very closely to the values of the indices of coefficients for speeds and lengths applicable to ships.

Such results were purely experimental and were not based on theoretical considerations, although Mr. Froude had foreseen that the resistance per unit area would diminish owing to the wake at the ends of the planks. More recently a theoretical law of similitude applicable to such resistances has been enunciated by Lord Rayleigh. According to this law the frictional resistance of similar surfaces varies as a function of the product of speed and a dimension. Thus, if, as Mr. Froude experimentally determinnd, the resistance varies as $V^{1.83}$ it should also vary as $L^{1.83}$, or the mean resistance per unit area as $\frac{(V L)^{1.83}}{L^2} = \frac{V^{1.83}}{L^{.17}}$. Mr. Froude's planks were not "similar," the breadths of all being 19in., and the results do not exactly confirm the law, yet they are sufficiently close to be within the limit of experimental error. Results which have been obtained by others experimenting in air agree very closely with those of Mr. Froude. The latter were reviewed and reconsidered by his son, Mr. R. E. Froude, and the power of the speed was altered slightly from 1.83 to 1.825.

Institution of Mechanical Engineers

On Friday evening, December 5th, two interesting papers dealing with the elastic properties and strength of metals were presented before the Institution of Mechanical Engineers. One by Professor F. C. Lea, of Sheffield University, dealt with the effect of low and high temperatures on materials, and the other by Mr. J. M. Lessells, of the Westinghouse Research Laboratory, East Pittsburg, discussed the elastic limit in tension and its influence on the breakdown of metals by fatigue.

Temperature and Strength.

To a certain extent Professor Lea's paper repeated what the author has previously published regarding the effect of temperature on materials. As regards low temperatures down to —80 deg. Cent. his experiments were very briefly dismissed, for they showed that as far as tensile strength is concerned the effect is not important. For two steels containing 0.32 and 0.14 per cent. of carbon tested at various temperatures between + 15 deg. Cent. and — 65 deg. Cent., there was little change in the tensile properties with variation of temperature, such change as there was indicating that the ultimate strength and the limit of proportionality had minimum values at the freezing point of water.

The effects of elevated temperature, were on the other hand, found to be very marked and of great practical significance. The steels tested consisted of the two carbon steels referred to above, four nickel-chrome steels containing from 0.15 to 0.35 per cent. of carbon, from 0.25 to 1.00 per cent. chromium, and from 1.25 to 4.5 per cent. nickel, and a steel containing 0.65 per cent. of carbon and 0.8 per cent. of manganese. Typical results for one of the alloy steels and one of the carbon steels are shown diagrammatically in Figs. 1 and 2 respectively. Up to

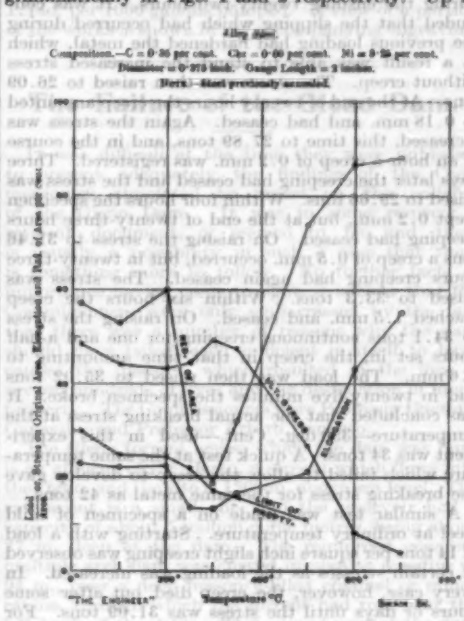

Alloy Steel.
Composition.—C = 0·35 per cent. Cr = 0·60 per cent. Ni = 0·35 per cent.
Diameter = 0·375 inch. Gauge Length = 2 inches.
Heat-Sheet previously annealed.
Tons per Sq. Inch, or Stress on Original Area, Elongation and Red. of Area per cent.
REDUCTION OF AREA
ELONGATION
LIMIT OF PROPORTION
"THE ENGINEER"
Temperature °C.
Sheet 56.

FIG. 1

about 300 deg. the ultimate stress increases following a slight fall at the outset and thereafter markedly decreases. Thus at 500 deg. the strength in both cases is only about half what it is at the normal temperature. The percentage elongation and the reduction of area have minimum values at the points of maximum strength. The actual shapes of the curves, it is found, depend upon the original condition and past history of the specimen. The curves for the maximum strength at temperatures in excess of 400 deg. are, Professor Lea points out, somewhat artificial. Their form is influenced by the fact that the tests were completed in a comparatively short

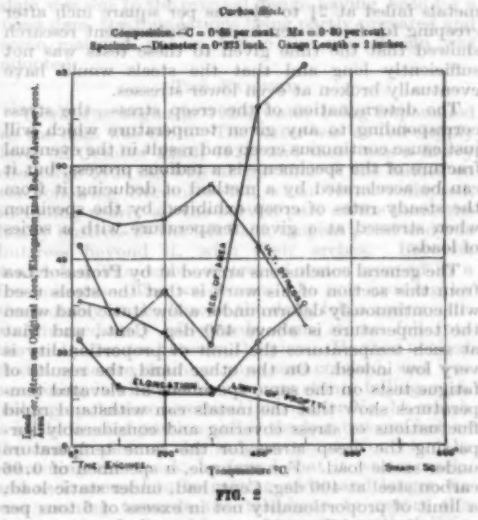

Carbon Steel.
Composition.—C = 0·65 per cent. Mn = 0·80 per cent.
Specimen.—Diameter = 0·375 inch. Gauge Length = 2 inches.
Tons per Sq. Inch, or Stress on Original Area, Elongation and Red. of Area per cent.
REDUCTION OF AREA
ELONGATION
LIMIT OF PROPORTION
"THE ENGINEER"
Temperature °C.
Sheet 56.

FIG. 2

time. As will be shown immediately, the determination of the strength of metals at elevated temperatures is rendered difficult and ambiguous by the phenomenon of "creep" in the extension which accompanies any given applied load.

The discussion of this phenomenon of creep constitutes the most important part of Professor Lea's paper. The author as a result of his researches advances the view that for any given temperature there is a particular stress which marks a critical change in the behaviour of the metal towards the applied load. If the stress is above this critical value the specimen will continue to extend more or less viscously and in time will end by fracturing without

any increase in the applied load. If the stress is below the critical value the specimen may or may not show this creeping of the extension. If it does so, the creep will eventually diminish and die out. In neither case will the specimen fracture. The author suggests that the creep initially observed when the applied load is below the critical value represents a viscous flow of the metal, and that the dying out of the creep represents the solidification of the viscous material. It is thus obvious that a metal at elevated temperature, if tested quickly, may give a fictitiously high ultimate stress; a lower stress, with the creep given time to develop, might cause failure.

As an example of the experimental results on which Professor Lea bases these views we will take the case of tests conducted on a specimen of 0.32 carbon steel at 350 deg. Cent. At this temperature a stress of 22.5 tons per square inch was applied to the specimen. At the end of five days the total creep on a length of 4in. was about 1.8 mm. and had ceased. The stress was then raised to 24.25 tons. No creep was observed during the ensuing twenty-two hours. It was concluded that the slipping which had occurred during the previous loading had hardened the metal, which as a result was able to stand the increased stress without creep. The stress was then raised to 26.09 tons. At the end of twenty hours the creep amounted to 0.18 mm. and had ceased. Again the stress was increased, this time to 27.89 tons, and in the course of an hour a creep of 0.2 mm. was registered. Three days later the creeping had ceased and the stress was raised to 29.66 tons. Within four hours the specimen crept 0.2 mm., but at the end of twenty-three hours creeping had ceased. On raising the stress to 31.46 tons a creep of 0.5 mm. occurred, but in twenty-three hours creeping had again ceased. The stress was raised to 33.3 tons. Within six hours the creep reached 1.5 mm. and ceased. On raising the stress to 34.1 tons continuous creeping for one and a-half hours set in, the creep in that time amounting to 0.6 mm. The load was then raised to 35.02 tons and in twenty-five minutes the specimen broke. It was concluded that the actual breaking stress at the temperature—350 deg. Cent.—used in this experiment was 34 tons. A quick test at the same temperature which failed to allow the creep to develop gave the breaking stress for the same metal as 42 tons.

A similar test was made on a specimen of mild steel at ordinary temperature. Starting with a load of 14 tons per square inch slight creeping was observed at certain stresses as the loading was increased. In every case, however, the creep died out after some hours or days until the stress was 31.09 tons. For half a minute this load was held. Then the specimen began slowly to creep for a few seconds, followed by a creep at the rate of 0.7 mm. per second, until it fractured. A specimen of the same steel tested in the ordinary manner broke at 30.2 tons per square inch. These tests, Professor Lea holds, indicate very clearly that what is generally called the breaking stress at ordinary temperatures is approximately that stress which will cause continuous creep. Moreover his tests show that this stress can be approached very nearly without continuous creep taking place.

Other tests carried out on the alloy steels at 600 deg. Cent. resulted in the specimens fracturing at from 6 to 8 tons per square inch after creeping for three to five hours. At 700 deg. Cent. specimens of these metals failed at 2¼ to 3½ tons per square inch after creeping for five to ten hours. Subsequent research showed that the time given to these tests was not sufficiently long and that the steels would have eventually broken at even lower stresses.

The determination of the creep stress—the stress corresponding to any given temperature which will just cause continuous creep and result in the eventual fracture of the specimen—is a tedious process, but it can be accelerated by a method of deducing it from the steady rates of creep exhibited by the specimen when stressed at a given temperature with a series of loads.

The general conclusions arrived at by Professor Lea from this section of his work is that the steels used will continuously deform under a low static load when the temperature is above 450 deg. Cent., and that at such temperatures the limit of proportionality is very low indeed. On the other hand, the results of fatigue tests on the same specimens at elevated temperatures show that the metals can withstand rapid fluctuations of stress covering and considerably surpassing the creep stress for the same temperature under static load. For example, a specimen of 0.06 carbon steel at 400 deg. Cent. had, under static load, a limit of proportionality not in excess of 6 tons per square inch, while at 16 tons a very large amount of permanent set was produced. Yet at 390 deg. Cent., under a fluctuating stress of ± 15.6 tons, the same metal withstood over 14 million stress cycles without failure. Subsequently, the same specimen withstood at the same temperature many million cycles of stress covering the range ± 18.25 tons. Even at 530 deg. Cent., it did not fail after many million reversals of a ± 7.5 tons stress. One of the alloy steels which at 700 deg. failed in 6 h. 10 min. by creeping under a stress of 2.71 tons, withstood without fracturing very many million reversals of a ± 17.5-ton alternating stress at 770 deg. Cent. At the same high temperature over 3 million reversals were required to fracture this metal at a stress of ± 22 tons. In all cases the stress cycles were applied at the rate of 2000 per minute. At that rate, it is obvious, the creep phenomena are given no time to operate in any marked degree. In this we find the explanation of the curious result revealed, namely, that at high temperatures metals may be loaded safely with an alternating stress considerably in excess of the static stress, which at these temperatures would eventually cause failure by creeping.

A study of the hardness of metals at elevated temperatures has also been made by Professor Lea, and reveals the fact that the hardness numbers reflect the tensile strength of the specimens, as determined in the ordinary way. They do not, however, show in any way the creep stress nor supply any information regarding the resistance of the specimens to reversed cyclic stresses.

Elastic Limit and Fatigue.

The paper by Mr. J. M. Lessells on the elastic limit in tension and its influence on the breakdown by fatigue was presented in the author's absence by Professor B. P. Haigh, of the Royal Naval College, Greenwich. One of the main objects of the paper is to show that if we know the endurance limit for a metal in one state, we can calcuate the endurance limit for another state, provided we have the tensile test figures for both states. The formula to be employed for this purpose is the simple hyperbolic one, $x\,k$ = constant, in which x is the ratio of the yield point stress to the elastic limit, and k is the ratio of the maximum positive or negative stress in the fatigue range to the ultimate stress as derived from an ordinary test, the metal throughout being in the one condition. For four normalised steels, containing 0.37, 0.52, 0.93 and 1.2 per cent. carbon, the values of the constant in the equation were 0.465, 0.450, 0.432 and 0.444 respectively. Experimenting with a steel containing 0.37 per cent. carbon and 0.59 per cent. manganese, the author found the endurance limit to be 28,000 lb. in the rolled state, 28,600 lb. in the annealed, and 29,300 lb. in the normalised. Determining the elastic properties of the metal in these three states, he calculated the endurance limits for the second and third states from the known limit for the first, and obtained the values 28,500 lb. and 30,000 lb. respectively.

The author explains the dependence of the endurance limit upon the ratio of the yield stress and the elastic limit, by stating that this ratio measures the state of internal stress in the specimen, which state affects the endurance limit. In addition to the internal stress, the microstructure, according to the author, affects the endurance limit. To illustrate this fact, the author tested two specimens of the same steel, both quenched from 850 deg. Cent., but one tempered to give a Brinell hardness of 207 and the other a hardness of 248. These two specimens gave 0.48 and 0.44 respectively as the value of k in the formula, that is to say, for the ratio of the endurance limit to the ultimate stress. In the annealed state this steel gave 0.415 as the value of this ratio. Other experiments with other steels have convinced the author that the ratio of endurance to ultimate stress is greater for heat-treated steels than for simple annealed steels.

In a second section of his paper Mr. Lessells criticised the results obtained by the quick deflection method of determining the endurance limit as developed by Mr. H. J. Gough, of the National Physical Laboratory. Particulars of this test were first published in The Engineer—see our issue of August 12th, 1921—and subsequently in report No. 743 of the Aeronautical Research Committee. It will be recalled that the deflection of the specimen is measured as the load on it is increased, and that the stress at which the deflection ceases to be proportional to the load is taken as the fatigue limit. From a lengthy series of experiments, carried out on a variety of metals, Mr. Lessells concludes that the deflection method gives good results for the endurance limit in certain cases in which it succeeds in placing that limit below the elastic limit of the material in tension. But in a number of instances the deflection method, according to Mr. Lessells, places the endurance limit above—sometimes considerably above—the elastic limit, and is therefore very misleading. For example, in the case of a 3 per cent. nickel steel, the deflection method was found to give 46,800 lb. as the endurance limit. The elastic limit in tension for this material was 31,500 lb., and the true endurance value as determined by the long or Wöhler method was 30,000 lb. For a brass, as rolled, the deflection method gave the endurance limit as 34,000 lb. Yet with the Wöhler method 1.3 million stress cycles at 27,000 lb. fractured the specimen. The elastic limit of this brass was 26,000 lb. On annealing the material the deflection method erred on the opposite side. It indicated an endurance limit of 18,000 lb., whereas this stress applied in a Wöhler type of machine failed to break the specimen after 4 million cycles. In the annealed state the brass had an elastic limit in tension of 9500 lb.

In moving a vote of thanks to the authors of the two papers and to Professor Haigh for his able summary of Mr. Lessells', Mr. Patchell dwelt upon the urgency and importance of Professor Lea's investigations to those engaged upon the development of high temperature, high pressure boilers and similar work. He recalled that the first attempt to study the effect of high temperatures on the properties of metal was made by a committee which was appointed in 1836 and which reported in 1837.

Mr. H. J. Tapsell, of the National Physical Laboratory, said that at Teddington much work had been done during the past four or five years on the strength of metals at elevated temperatures, particular attention having been devoted to the phenomenon of creep. He understood that Professor Lea was under the impression that he was the only worker to have dealt with it, but in believing so he was wrong. Dickinson in September, 1922, discussed it in a paper, "Some Experiments on the Flow of Steel at Low Red Heat," which he read before the Iron and Steel Institute. Chevinard, in France, had also studied it, and in America one or two workers had investigated it, although not perhaps very thoroughly. Professor Lea's method of attack was not new, Chevinard's being precisely the same. At the National Physical Laboratory the importance of creep was recognised during the war, when steels for valves were being tested at high temperatures. At the present moment the subject was being studied for the Engineering Research Board. Professor Lea, he held, had based his conclusion upon tests of comparatively short duration. His own work taught him that creep did not necessarily become constant after a few hours or even a few days, but frequently only after some weeks. In one instance, the creep did not become constant after 142 days, even although by that time the elongation amounted to 11 per cent. of the original length. In another case the rate of creep did not become steady until 30 days had elapsed. It continued constant for many days, and then began to increase, the specimen finally breaking on the seventy-ninth day. By working only upon the early portion of a curve, and plotting that portion to an open scale, wrong conclusions must be arrived at. The policy of the Laboratory in this respect was to undertake long-time tests on a few materials, rather than short-time tests on many. Professor Lea, he observed, stated that the temperature of his specimens during the tests was kept to the prescribed value within ± 5 deg. Cent. At the National Physical Laboratory the variation of the temperature from the mean was within ± 2 deg. Cent. That point was of great importance, for a change in the temperature of the specimen by as much as 10 deg. might multiply or divide the rate of creep by 5 or even 10 in some cases.

Turning to the determination of the fatigue limit, he remarked that at the National Physical Laboratory after the limit had been found, a test was run at a slightly reduced stress for 10 to 12 million cycles, in order to confirm that failure would not occur at such stress.

Sir Henry Fowler thought that it was important to determine the effect of shock at low and high temperatures. Too much attention, he suggested, was being paid to the phenomenon of fatigue, and there were too many theories in explanation of it in existence. It was disturbing to learn that at high temperatures creep could be induced by relatively small loads, but he shuddered to think what it would mean if one had to specify that materials should be subjected to tests requiring 79 and 142 days or more for their completion.

Professor Philpot emphasised the necessity for starting tests of the nature dealt with in the papers with the metals in a known condition. Many of the difficulties in understanding and interpreting the results of tests on the properties of metals were to be ascribed to the fact that the specimens were at the outset in an unknown condition. In Professor Lea's paper this condition was given proper attention, but in Mr. Lessells' he found it stated that the deductions were not to be applied to heat-treated material, for which reason he felt inclined to distrust Mr. Lessells' figure.

Mr. H. J. Gough, of the National Physical Laboratory, attacked Mr. Lessells' paper strongly. The paper, he said, attempted to deal with one of the most complex phases of the phenomenon of fatigue, yet the author suggested that it could all be expressed by means of a simple formula. If that formula were correct, it would be a boon to engineers, but if it were wrong its use would be highly dangerous and would in practice bring crashes in its train. Apparently, it did not matter what the yield point or elastic limit was. So long as their ratio was the same, the endurance limit, according to Mr. Lessells' formula, would not be affected. Mr. Gough deduced figures relating to the properties of Armco iron to show that that conclusion could not be supported. Other figures which he gave the meeting showed that Mr. Lessells' formula gave results for the endurance limit, which, in turn, were in error as checked against the experimental figures by − 72, − 11 and + 39 per cent. The shock-resisting properties of a metal were really more important to designers than the fatigue limit. The degree of resistance to shock possessed by a metal was not always indicated by a tensile test, and never by a fatigue test. For a boiler plate, which, after failure, had been submitted to the National Physical Laboratory, the fatigue limits for the metal as received and as correctly heat-treated were the same, and the tensile strengths were nearly the same. The only important difference between the metals in the two states was revealed by the Charpy

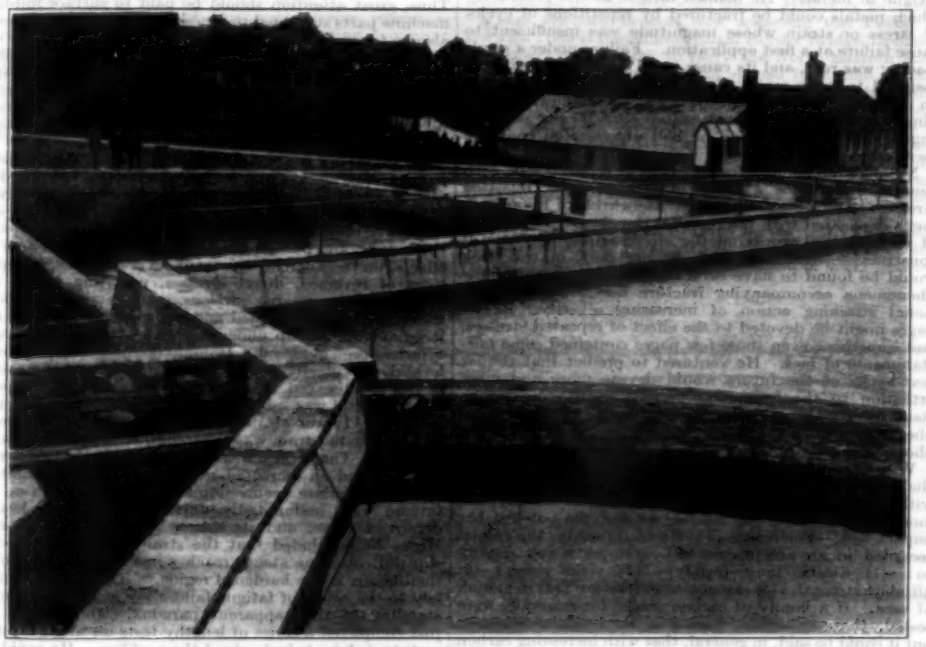
impact test, the figures for which for the untreated material was 0.8 and for the treated over 6. The truth was that the ability to suffer plastic deformation was a more important property in a metal than the possession of complete elasticity. For example, scratches on the surface of a member caused, as was well known, a concentration of stress in their neighbourhood. Such concentration would be released by plastic slip; it would not be released if the metal were wholly elastic. Turning to Mr. Lessells' criticism of the quick or deflection method of determining the fatigue limit, he disclaimed the credit for its inception. It was, he said, first proposed and tried by Dr. J. H. Smith. The National Physical Laboratory merely adapted and developed it. In ductile metals the departure from proportionality between the load and the extension was very marked, and unmistakable. But in harder materials the departure was often very difficult to detect with precision, and in the hands of inexperienced workers the method could certainly, from that cause, be open to considerable error. It undoubtedly had defects, and he would be glad of any contributions from Mr. Lessells or anyone else that would help to improve it.

Dr. B. P. Haigh desired to reserve his decision regarding the value of the deflection test for the fatigue limit. Opinion, he thought, was changing as to the value of the information revealed by a fatigue test regarding the relative safety and strength of metals when subjected to alternating stress. There was something more behind the matter than the resistance to fatigue. Ductility as well as the fatigue strength undoubtedly played an important part. Metals with a low ductility subjected to alternating stress required a factor of safety greater than that required with a metal of the same fatigue strength, but having high ductility. The variation in the factor of safety from that cause might be as great as 2 to 1. Creeping could occur under alternating stress, and at ordinary temperatures. It was not always in those circumstances a danger, but sometimes acted as a safeguard.

Professor Lea said that so far as his experience went, the deflection method was fairly satisfactory for mild steel in the normalised condition, when subjected to equal plus and minus stresses. Outside those conditions, however, it was open to some doubt. Replying to Mr. Tapsell, he disclaimed originality for the discovery of the phenomenon of creep. Fairbairn, Kelvin and others in the past had frequently mentioned it. The novelty in his treatment of the subject was confined to the idea of a limiting or critical value of the stress at any temperature at which the creep ceased to die out and became continuous. He agreed that it was very difficult to determine the rate of creep with precision, and admitted that his method of finding the critical stress at a given temperature was a little arbitrary, but he maintained that the method worked fairly well. As to the necessity for maintaining the temperature of the specimen during a test as constant as possible, he was in full agreement with Mr. Tapsell's remarks. In fact, in his paper he had emphasised the point that a change of temperature ought to be guarded against with even greater care than a change in the load. Concluding, he expressed his inclination towards a belief that above a certain temperature, such as 700 deg. or 800 deg. Cent., metals possessed no fatigue range at all. Ordinarily, at common temperatures, 10 million reversals of stress successfully borne might be held to establish the fact that the stress was below the fatigue limit. At high temperatures, it was, he felt, quite possible that under quite a low stress a specimen might sustain 500 million reversals before it fractured.

New Waterworks in Guernsey.

There are two separate and distinct supplies of water in the Island of Guernsey, one being for drinking and domestic purposes, and the other entirely for greenhouses. The water for the latter is obtained from disused quarries and for the former from seven wells and two streams. For some years prior to 1921, when the States, or local governing body of the Island, took over the works from a company, a shortage of water had been experienced, and in 1921 Guernsey shared in the suffering caused by the widely prevalent drought. During that year, after careful consideration of the gaugings of the largest stream in the Island, it was decided to construct new works on that stream at a place known as Kings Mills. The works were designed to deal eventually with 30,000 gallons per hour, or 720,000 gallons per day, divided into three sections of 10,000 gallons per hour each. Two of the sections have now been completed, and the works comprise a settling reservoir, with a capacity of 700,000 gallons, a pre-filter, three open sand filter beds (two of sufficient area to deal with 5000 gallons per hour each and one with 10,000 gallons per hour), two clear water tanks of 110,000 gallons capacity each, and pumping machinery.



A PORTION OF THE NEW WATERWORKS IN GUERNSEY

Though two trial holes were made before designing the works, the formation met with over the greater portion of the area was found, when the excavation was nearing completion, to be exceedingly bad, and the walls and floors had, in consequence, to be increased and strengthened, the concrete being reinforced by steel rails and mesh reinforcement. That fact, and the necessity of having to use the works before their completion, caused considerable delay, but the first section of the machinery was put into use in July, 1923, and the second section in June of this year.

A waste-water channel is provided; so that when the stream is discoloured it is not taken into the settling reservoir. The pre-filter, which consists of granite siftings, is constructed at the intake end of the settling reservoir, and delivers the water at the bottom of the reservoir. At the far end of the reservoir, the water is drawn off by means of a floating arm at 6in. to 9in. below the surface, and conducted by pipes to the filters. The rate of filtration is 450 gallons per square yard of the filtering area per twenty-four hours, or 4in. depth of water per hour. The filters consist of 3ft. depth of sand, below which is 1ft. 6in. of shingle graded into four grades, that on the top or nearest the sand being of particles ⅛in. to ¼in. diameter, and the lowest grade being between 1in. and 2in. diameter. On the floor of the filters brick drains collect the water into a central channel. At the outlet of each filter there is a chamber where the flow of water is ascertained by means of a weir, and regulated by sluice valves. The filtered water, before being allowed to flow into the clear water tanks, is chlorinated, the Chloronome being supplied by the Paterson Engineering Company. The clear water tanks are constructed of masonry and concrete, and have flat concrete and steel girder roofs, supported by cast iron columns. The pipe arrangement is such so that all or any of the filters can be used at the same time, and either or both clear water tanks. Separate pipes from each clear water tank are laid to a small pump well.

The contractor for the works was Mr. N. Buckley, of Weymouth. The pumping machinery is housed in the old Mill House, a substantial stone building, and consists of a duplicate plant to lift a total of 20,000 gallons per hour against a head of 279ft. when both plants are running at the same time. Contracts for this machinery were let to Worthington-Simpson, Limited, of London and Newark. The pumps are of the three-throw vertical plunger type, direct geared, and driven through friction clutches by crude oil engines, manufactured by Ruston and Hornsby, Limited, of Lincoln. We understand from Mr. G. H. Perryn, the engineer to the States waterworks department, that the fuel consumption works out at 0.53 lb. per pump horse-power per hour. The total working cost of the plant without labour is 1.14d. per 1000 gallons pumped. A view of a portion of the works is shown in the accompanying engraving.

The Failure of the Gleno Dam.

It was difficult at the time they were published to present adequately the findings of the Commissioners appointed to report on the collapse of the Gleno Dam. It was in some respects a reticent document, or seemed to be, and there is usually a possibility in such a case that there is something more to follow. No further facts of importance having come to light, it is clear that the Commissioners were only embarrassed by the fact that there was a number of reasons why the dam should have failed, each sufficient in itself to have caused the disaster, which resulted in the loss of several hundreds of lives and the destruction of much property. The Commissioners were Professor Gaetano Ganassini and Professor Arturo Danusso.

The Gleno torrent across which the dam was built is an affluent of the Dezzo, a stream which flows into the Oglio, and the site is 1500 m. above sea level. The catchment is a small one, and the reservoir had a capacity of about 5 million cubic metres, being about 27 m. deep at the dam. The reinforced concrete multiple arch dam was curved in plan to a radius of 94 m., over a deep masonry-filled channel or minor ravine, through which the torrent had run, near the left bank of the defile. This curved part of the dam had a length of 72 m., and was connected with the banks by tangential straight portions, 48 m. to the left bank and 100 m. to the right bank. It had twenty-seven inclined arches and twenty-six buttresses. The maximum height, including the masonry filling the channel, was about 50 m., elsewhere about 30 m., the straight portion of the multiple arch dam resting on the rock. The buttresses were 8 m. apart, centres, with a maximum base width of 30 m. The thickness at the base of the highest buttresses was 3½ m., tapering to 1.9 m. at the tops. The mass masonry foundation was pierced by a tunnel 4 m. wide and 10 m. high, intended for the emptying of the reservoir. The buttresses at the tangent points were 4 m. thick throughout. The curved form given to the dam was due to the original design having been for a mass dam, the foundations being partly prepared and some masonry put in before the new design was adopted.

The Failure.

Work was begun in 1920, water being impounded as the dam was built. The water was at full supply level on October 22nd, 1923, and there was a heavy discharge over the weir at the time of the failure on the following December 1st, when 70 m. collapsed, including nearly all the curved part of the dam, the heavy buttress at the left bank tangent point and one buttress beyond it, with their arches. Between 4 and 5 million cubic metres of water escaped in a few minutes. The watchman, who was crossing by the footway at the base of the dam, felt a movement, and immediately afterwards some stones fell into the pools of water between the piers. He then noticed that a concrete drainage pipe was cracked, and was examining it when he heard more stones falling, and, looking up, he saw a vertical line on pier No. 11, which is in the curved portion and is the last but one before the heavy pier at the tangent point No. 14. On examining this mark, he found that it was a crack, and as it seemed to be getting wider and longer, he was running towards the telephone to report the matter, when he heard large pieces of concrete falling and saw the pier break in two, the two arches collapse, and then the crumbling of the adjacent portions of the dam and a rush of water. The superstructure was destroyed from pier No. 3 to pier No. 12, the piers at the tangent points being Nos. 5 and 14. The masonry base was cracked horizontally, and was deeply eroded, the rock having been exposed in some places.

The Findings of the Commissioners.

The Commissioners could not find any definite, immediate cause of the failure, but they consider that the superstructure was statically insufficient, that the base was on the point of failure from the time that the reservoir filled, and that it was further weakened

by continuous leakage. An arching effect could not be developed in this mass of masonry, since the rock at the sides of the ravine at the bottom of the defile had not been cut to form springings, and the drainage tunnel prevented the transmission of horizontal thrust. Although, in the light of the watchman's report, a local defect in the superstructure might have been supposed to have caused the failure, this explanation is rejected because other piers survived the collapse, and because the dam had held its full head of water for more than a month. The failure must have been gradual, and, almost certainly, in the base, the fundamental cause being the weakness of the supporting masonry under the curved part of the dam. It was neither big enough nor strong enough. The suggestion that an earthquake might have caused or precipitated the failure was rejected, no earth tremors having been recorded at the nearest observatories. The report includes strong criticism of the design and the execution of the work. The masonry base was built on a rock surface which sloped downstream, and was neither trenched nor stepped. Lime mortar, and that of a poor quality, was used in its construction. The leakage, most of which was through and under the foundation, was estimated to amount to more than four cusecs, and had begun in 1921. An independent witness testified that a short time before the failure water was spouting from some of the piers and from one arch.

The specifications provided for cement mortar in the masonry base and cement-lime concrete in the superstructure. For the arches and parts of the piers 150 kilos. of cement and 100 kilos. lime per cubic metre. For the remainder of the piers, 100 kilos. of each per cubic metre, with large stones in addition. More than half the base was, however, built with lime mortar, some of the bases of the piers were built with cement-lime concrete, and the arches, piers and the remaining bases of the piers with cement concrete, in which, for the arches, the proportions of cement ranged, or were supposed to range, from 250 kilos. down to 200 kilos. per cubic metre, and for the piers and their bases, except as already noted, from 200 kilos. down to 150 kilos. per cubic metre. After the failure, however, tests of portions of the concrete pointed to an average proportion of not more than 100 kilos. of cement per cubic metre in the piers, and serious, though not such great, deficiencies in the arches. The sand and gravel, according to dependable witnesses, had not been properly washed. The quality of the masonry in the base was exceedingly bad.

Some Independent Criticisms.

Amongst the independent criticisms of the work which have been published, some of the points dealt with in the official report are strongly emphasised, especially the downstream slope, unstepped, of the rock surface upon which the base was built. The fact that reinforcement rods, which would have broken when the dam failed if the structure had been normally built, were torn out of the concrete, is noted. A Swiss engineer, M. Stucky, who visited the site after the disaster, made calculations which show that there were small tensional stresses in the piers, objectionable, but not sufficient to have caused the failure. A study of the shears showed that the tangential tensions did not exceed 5 kilos. per square centimetre (4.6 tons per square foot or 71 lb. per square inch). From evidence, supported by photographs, two piers are believed to have collapsed by shearing. M. Stucky attempts to reconstruct the failure. He believes that the buttresses were stressed to the limit of their strength by the time that the reservoir was full, and probably several of them showed signs of shear before the failure. Even without the contributory cause of the failure, namely, the leakage between the rock and the masonry, which caused the collapse of the first pier that failed, the dam would have collapsed by the shearing of other piers and the resulting disintegration of the concrete.

* * * * *

The short and tragic story of the Gleno Dam reads less like a record of human errors than a tale of the workings of some supernatural and sinister power. The scene was laid in a mountain valley nearly 5000ft. above sea level, and remote from the chance observation of educated and responsible persons. Step by step, during the planning, the building, and using of the dam, no chance of making a vital or minor error or of defaulting in matters essential to safety seems to have been neglected. The first wrong step was taken when the design for a mass dam was abandoned and the evil legacy of the curved foundation handed on to form a feature ensuring the development of small but objectionable stresses. As though this bad beginning were not enough, some strange perversity led the designers to make its effects worse by introducing a massive pier at each tangent point, thus making it impossible for the small horizontal thrusts of the major curve to be absorbed in part by the elements of the straight wings of the dam, but, on the contrary, confining the elastic deformation as far as possible to the minimum number of elements. Next, the mass of masonry in the base was deliberately founded on a rock surface which sloped downstream, and was not stepped nor trenched, but merely roughened to a small extent. As though to clinch the matter, the cement mortar specified for this masonry was given up in favour of lime mortar, and, as a last touch, this masonry, not protected by a bank of clay or other impermeable covering, was exposed to a gradually increasing water load as the dam was raised. In the superstructure, the by no means liberal proportions of cement or lime and cement given in the specification were cut down to half and less than half in the actual building. Displacers were used where homogeneity was specially desirable. The already barely adequate dimensions of the piers were, in one or two cases, made even less adequate by wrong placing of the bases. The steadily increasing leakage was allowed to go on unchecked. The last hope was a countryman who frequently passed the dam and noticed rapidly increasing leakage and jets of water in the days before the disaster, and he failed to report the matter to any official or responsible person, who might have taken action. Lastly, the failure occurred in the early dawn, when the watchman, though he was on duty at the time, had had no opportunity of noticing the first signs of failure, so that the few but precious minutes which might have saved many of the victims were denied. As a final touch of the grim irony of fate, the factories, when the dam gave way, were telephoning for more water.

Fatigue in Metals.

In a lecture to the British Acetylene and Welding Association, at the Old Colony Club, Aldwych, London, on Thursday, December 4th, Mr. H. J. Gough, of the National Physical Laboratory, discussed the problem of fatigue in metals. He defined fatigue as the process by which metals could be fractured by repetitions of cycles of stress or strain whose magnitude was insufficient to cause failure at a first application. Failure under a single loading was rare, and its cause could usually be definitely assigned to gross errors of design, faulty material, or to an unforeseen shattering overload. An eminent Scandinavian engineer had once stated that 90 per cent. of engineering failures which he had investigated could be ascribed to fatigue.

No engineer could afford to neglect a subject of such general importance as that of failure under repeated stresses. Discussing the present knowledge of the phenomena associated with fatigue, Mr. Gough said that if one of the standard works on the strengths of materials of construction were consulted, 90 per cent. of the book would be found to have been devoted to a study of the phenomena accompanying fracture due to a uni-directional straining action of increasing severity. A few pages might be devoted to the effect of repeated stresses, and sometimes even those few pages contained some misstatements of fact. He ventured to predict that similar text-books of the future would devote more and more attention to the fatigue properties, until some day a classical book would be produced in which statical phenomena were studied in close relation with fatigue phenomena.

With regard to the use of fatigue tests as quality tests, the lecturer pointed out that, of the acceptance tests with which materials of construction had to comply, the most common were the tensile test and the notched bar impact test. For reasons chiefly of economy, the results recorded in an acceptance test were restricted usually to:—(1) Elastic limit (rarely); (2) yield stress; (3) ultimate strength; (4) elongation at fracture; (5) reduction of area. If a family of carbon steels, for example, were tested, those quantities varied in an irregular manner; but it could be said, in general, that with increasing carbon content the ultimate strength increased and the ductility decreased. The resistance of a metal to shock could be affected profoundly by heat treatment. Moreover, in many cases faulty heat treatment could not be detected from the results of a static tensile test. There was little doubt that faulty micro-structure was most clearly revealed by a notched-bar impact test, of which the form usually adopted was the Izod test.

The question arose as to whether such tests could be dispensed with if the fatigue range of a material had been determined. Mr. Gough said that he had data of the results of reversed bending tests made on 106 metals, collected from the records of three distinct laboratories. The results showed that there was no relation between the fatigue range and the tensile limit of proportionality, the yield stress and the impact value—single blow to fracture—respectively. He then discussed the relation between the fatigue range and the ultimate tensile strength, and concluded that the only mechanical property with which the range for reversed bending stresses could be correlated was the ultimate tensile strength. It might be mentioned that, as the Brinell number was directly related to the ultimate tensile strength, a very accurate estimate of the fatigue range might be obtained by carrying out a ball indentation test on a specimen.

The relative fatigue resisting properties of two metals bore no relation to their notched bar values. Hence, it would be assumed that the fatigue range was not affected by faulty heat treatment if the ultimate strength were not affected. That, also, had been proved by several investigators, and some results bearing on the point were given, the important fact brought out being that if a material were to be subjected to repeated stresses and to occasional heavy shocks, the choice of that material must be made after a careful consideration of its tensile strength and its shock-resisting properties. In other words, the fatigue test in itself was not a quality test. For instance, if a motor car designer were to attempt to reduce the weight of a propeller shaft by using a very high carbon steel, in the hardened condition, in that way obtaining increased fatigue range at the expense of ductility, that designer would be asking for trouble. He would certainly encounter it, owing to the usual appalling misuse of brakes and clutch.

With regard to permanent deformation resulting from repetitions of a safe range of stress, the lecturer said that the subject had been studied fully by Bairstow. His examination of an axle steel showed that permanent set resulted from every range of safe stress, except reversed stresses. The amount of the set depended on the maximum stress of the cycle. When that stress was equal to, or greater than, the static tensile yield stress of the material, the permanent set was equal to that obtained in a static test. When the maximum stress of the cycle was less than the tensile yield stress, the set produced by repeated stress exceeded that resulting from the first application of the stress. The practical significance of that result might be expressed by saying that if, in any structural or machine component subjected to repeated stresses permanent set could not be permitted, then the maximum working stress must not exceed the limiting stress for reversed stresses, if the latter were less than the static elastic limit, or the static elastic limit if its value were less than that of the limiting stress.

Discussing the effect of surface scratches and discontinuities of section on the fatigue range, Mr. Gough pointed out that it was an established fact that surface defects whose effect on the static ultimate strength was negligible, might considerably affect the fatigue-resisting properties of the same material. Important research had recently been carried out by Thomas on the effect of scratches and of various workshop finishes upon the fatigue strength of steel, and his results were as follows:—

Type of finish.	Estimated maximum reduction in fatigue strength. Per cent.
Turned	12
Coarse file	18 to 20
Bastard file	14
Smooth file	7½
Coarse emery (No. 3)	6
No. 1 emery	4
Finer emery (O or FF)	2 or 3
Fine carborundum	2 or 3
Fine ground finish	4
Accidental scratches (maximum found)	16

Thus, great attention should be paid to surface finish of machine parts subjected to repeated stresses. Care should also be taken to avoid sudden changes of section. It was his experience that the effect of a right-angled shoulder or collar on a Wöhler specimen reduced the fatigue range by 50 per cent. If a change of section were necessary, care should be taken to connect the two unequal sections by a smooth transition curve, which should be as long as possible.

As to the effect of repeated stresses upon the micro-structure of metals, the author reviewed the work done and the theories which had been held as to the mechanism of slip in crystallographic planes, fatigue, &c., and subsequently referred to the results of research conducted at the N.P.L., and published last year. In that research the effects, on the micro-structures of several metals, of repetitions of reversed, direct stresses, pulsating tensile and pulsating compressive stresses, and reversed torsional stresses, had been studied and indisputable evidence of a large amount of slip under safe ranges of stress of every type had been obtained. It might be considered as proved, he said, that plastic strain—as measured by strain measurements or observed as slip bands—could and did occur when a metal was subjected to repetitions of a safe range of stress. It was also an established fact that the result of such plastic strain was to strengthen and to harden the material. That effect was shown by an increased tensile strength and an increased resistance to ball indentation. Yet when failure occurred under repeated stresses, the fatigue crack undoubtedly started in one of the heavily deformed areas, and its course followed similar areas. Hence he concluded that the strain hardening effect of slip did, at some stage, reach a maximum, and failure then began in the hardened region. The long sought for key to the riddle of fatigue failure lay in a correct understanding of that apparent paradox. The N.P.L. had just completed a series of lengthy tests on single crystals, and, he believed, had solved the problem. He could not refer to that work, however, in fairness to his colleagues, as the results were in course of publication, but he was firmly of opinion that many hitherto baffling aspects of the problem had been solved.

A Water Tower of Unusual Design.

A water tower or elevated tank of unusual form and presenting some interesting features of design, is described by Sr. Alberto Laffon in the November issue of the *Revista de Obras Publicas*. It was designed and built by the engineers of the Madrid–Zaragoza–Alicante Railway, for the latter's new workshops at Villaverde. It is constructed of reinforced concrete, is shaped exactly like a long-stemmed liqueur glass, and is called the "Copa de Villaverde." The base of the visible structure forms the roof of an underground tank, and the slender, tubular stem supports the upper tank. This stem contains the supply and overflow pipes, and a ladder which passes up a cylindrical continuation of the stem to the roof of the tank, the opening being closed by a skylight. The underground tank is annular, with an outer diameter of 10 m., and there is an inner drum having a diameter of 2½ m. The depth is 3.0 m., and the capacity 166 cubic metres, or, say, 36,500 gallons. The upper reservoir has a diameter of 5.9 m., and its edge is 18.13 m., or nearly 60ft. above ground level. The depth is 4.95 m., and the capacity 107 cubic metres, or, say, 23,500 gallons. The hollow column has an internal diameter of 0.9 m. Just under the tank its wall is 0.25 m. thick, but the thickness increases towards the base nearly according to a hyperbolic curve. Externally it tapers from 1.8 m. diameter at the base moulding to 1.4 m. at two-thirds of its height, increasing again to 1.5 m. at its junction with the moulding of the upper tank. Below the visible base the column is continued in the form of the drum already mentioned, which has a wall thickness of 0.8 m., and terminates in a small chamber situated axially below the underground tank. This chamber is 1.5 m. in diameter, and contains an electric pumping set which lifts the water to the upper tank. Access to this chamber is by means of a small shaft and underground gallery.

The most important calculation of stability, that for

wind, was based on the formula $P = K S V^2$, the coefficient K having the value $\frac{5}{8} \times 0.08$. The records of the Madrid Observatory give a maximum velocity of 19 m. per second; say, 62.3ft. per second, or nearly 42½ miles per hour at ground level. At 2000ft. altitude the maximum recorded is 40 m. per second, or 89½ miles per hour. This was taken as the basis of the calculation, and was interpreted as corresponding to a pressure of nearly 85 kilos. per square metre, or 17.4 lb. per square foot on the axial section. To allow for sudden gusts the final value of 100 kilos. per square metre was adopted, the designers pointing out that this closely approximates the value of 20 lb. per square foot employed in British practice in the design of tall chimneys. For the calculation of the stability of the structure as a whole it was treated as a monolith, with both reservoirs empty, and it was found that the resultant force would not pass outside the central drum of the underground tank.

Although the design of this water tower resembles in principle that of other structures, including columnar water towers, its special features justify some description of the nature and placing of the reinforcement. The floor of the lower tank is 0.5 m. thick. It is reinforced by 16 main beam elements each 50 cm. wide and 30 cm. deep, uniting in the reinforcement of the central drum. This floor rests on hard clay, which also encloses the underground tank up to ground level. The outer ends of the main beam elements are connected by a ring element of similar form, 20 cm. by 30 cm., the base being, therefore, a polygon of 16 sides. Over this is the floor slab, 15 cm. thick, reinforced by concentric rings formed of rods having diameters of 6 and 10 mm. The outer wall of this tank, which is 30 cm. thick, is reinforced with horizontal rings, the rods having diameters decreasing from the floor to the roof. There is also vertical reinforcement. This wall is stiffened by 16 counterforts, corresponding to the main beam elements in the roof, the base of the visible structure. These 16 roof beams are radial and monolithic with the roof slab and "moulding," and taper in plan from the central drum to the outer wall, where they unite with the counterforts.

In the calculations for stresses it was assumed that the ground on one side might give way to some extent, the structure tending to tilt as a whole, and it was found that that could take place without the formation of leakage cracks. The vertical reinforcement of the column consists of rods 12 m. long, arranged in concentric rings, and the secondary reinforcement of hoops made of 6 mm. diameter rod. The maximum stresses allowed were:—40 kilos. per square cm., or nearly 570 lb. per square inch on the concrete; 600 kilos. per square cm., or nearly 8530 lb. per square inch on the steel in tension; and 500 kilos. per square cm., or nearly 7110 lb. per square inch on the steel in compression. The upper tank has a wall thickness of 50 cm. at its junction with the column, the thickness decreasing to 10 cm. at its rim. The calculations of the stresses in the tank were made by treating it as an inverted dome; also by treating the radial elements of the reinforcement as curved beams, a severe supposition, since all these elements are united transversely. The cost of the work per cubic metre of concrete was 340 pesetas, or just over £10 at the present rate of exchange.

New Bridge Over The Tweed.

Among the road bridge schemes which have recently received consideration, two of the more important are those for crossing the Tay and the Tweed. The proposals for giving facilities for road transport over the Tay at Dundee are still under review, and a fresh report on the engineering features is awaited, but the plans for a new bridge across the Tweed have been approved and a contract placed for the work with Messrs. Holloway Brothers.

There are two bridges now spanning the Tweed at Berwick; one is the famous Royal Border Bridge, designed by Robert Stephenson, to carry the North-Eastern main line over the river, which was opened for traffic in 1850 by Queen Victoria; the other is the old road bridge which dates from 1634. The railway bridge is a stone structure rising to a height of 126ft. It is nearly half a mile in length, and is built on a curve in a series of 28 arches. The road bridge, also of stone, is composed of 15 arches, and is 920ft. long. It is very narrow and has awkward approaches on both sides of the river. It has long since been recognised as unsuitable for modern traffic.

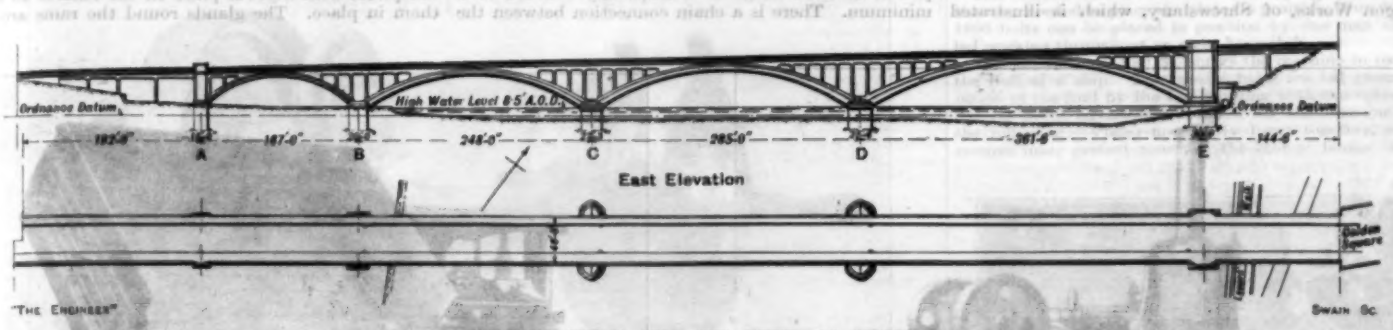
There has been a road bridge across the Tweed since the days of Kings Alexander and John of Scotland, and having regard to the fact that State aid is being granted for the building of the new bridge, it may be mentioned that a grant for the upkeep of the bridge over the Tweed was made as long since as the reign of Charles II., and is still in force.

In the preparation of plans for the new bridge the question of cost was an important consideration, and preference was finally given to a design in concrete and reinforced concrete which has been prepared by Messrs. L. G. Mouchel and Partners. The main features of the bridge and some details of the main river span are illustrated in the accompanying engravings, and it should be mentioned that special attention has been given to secure good approaches and to give an easy gradient in the fall from the Scottish to the English banks of the river. The design makes provision for a structure of 46ft. wide, which will give a 30ft. roadway and two footways of 8ft. Preliminary borings have shown that good foundations can be obtained for the piers in the rock and gravel formation underlying the river bed, and preparations are now being made for sinking the cofferdams for the piers. The latter will be carried down to a general depth of about 18ft. below Ordnance Datum, and the headroom under the main river arch will be 46ft. at high water.

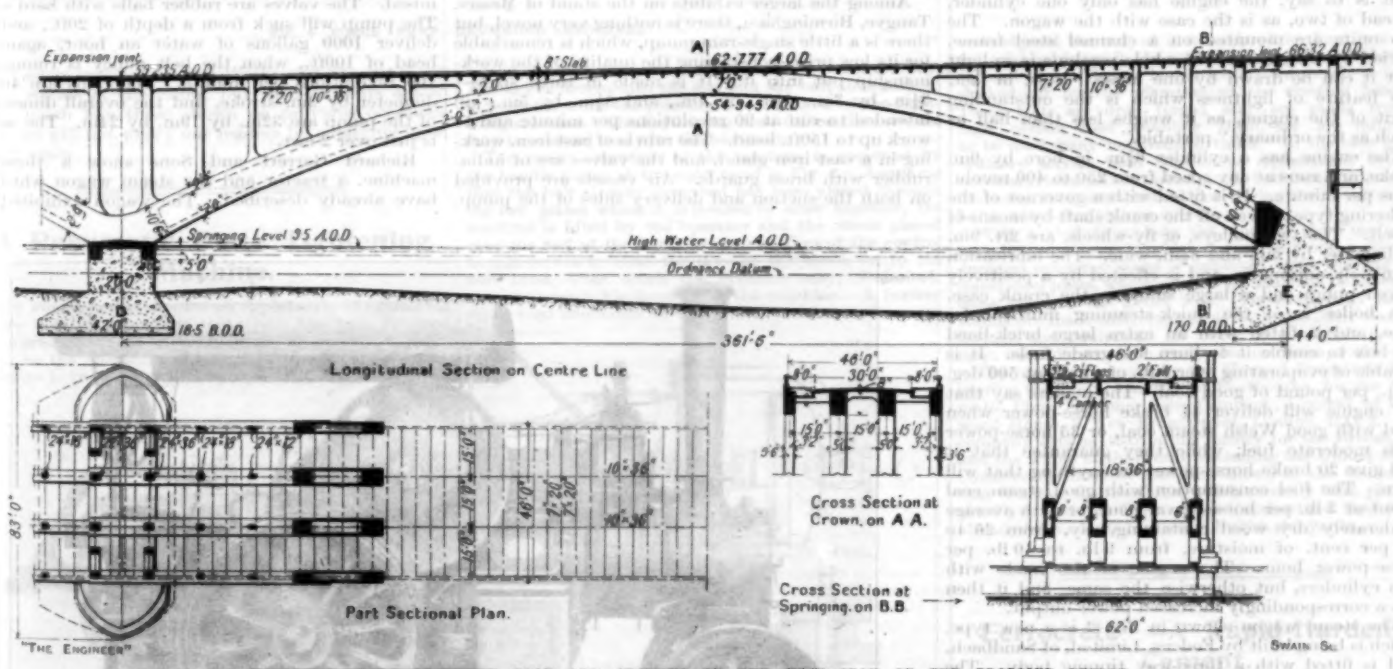
The bridge has been designed to rest on five main piers and will comprise four arches and two approach spans, making up a total length of 1405ft. The approach spans will be 144ft. 6in. and 199ft. respectively, and the arch spans 167ft., 248ft., 285ft., and 361ft. 6in. The large span, which will be on the Berwick side of the bridge, will, we believe, constitute a record for reinforced concrete construction in Great Britain. The general design of the arch spans, as indicated by the accompanying details of the largest span, will include four arched ribs hollow from their springing point for a third of the length of span, the centre portion being solid. From the arch spans vertical supports will be carried up to decking level. The vertical columns, which will connect the ribs with the decking, will vary in size, but the general design of decking is that of a reinforced concrete slab 8in. in thickness having transverse beams 2in. wide and 20in. deep, and longitudinal beams connecting the uprights 10in. wide by 30in. in depth. Expansion joints will, of course, be provided in the decking over the piers. The paving of the roadway will consist of 2in. of asphalt laid directly upon the reinforced concrete slab.

In the case of the main arch the ribs will be 10ft. 6in. deep at the springing and 7ft. deep at the crown. The width of the centre ribs is 5ft. and of the external ribs 3ft. 6in. The span has been designed in accordance with the regulations of the Ministry of Transport to carry a moving load of 1350 tons. The actual loads made up of an engine and three trailers are 20 tons for the engine and 13 tons for each trailer, making 59 tons, to which has to be added 50 per cent. for impact. This load is carried on a length of 70ft., and from these figures the moving load for which the arch has had to be designed is obtained.

The work is expected to occupy a period of 2½ years. The price, including purchase of land, has been fixed at £160,000. Towards this expenditure the Ministry of Transport will contribute 75 per cent., the balance being found by local authorities in proportions which have now been agreed. The engineer representing the local authorities is Mr. J. A. Bean, the county surveyor of Northumberland, with whom is joined for consulting purpose the chief engineer of the Ministry of Transport.



PROPOSED BRIDGE OVER THE TWEED AT BERWICK



ELEVATION, PART SECTIONAL PLAN AND SECTIONS OF THE MAIN SPAN OF THE PROPOSED BRIDGE

THE objection to gravitational shunting is that the wagons have to be followed up and the brakes applied before they come into contact with the other wagons standing in the sidings. One way of meeting it has been to provide skates on which the leading wheel rides, thus retarding the movement of the wagon. Visitors to the recent railway exhibition in Germany saw an arrangement there where tilting bars were used, which, when depressed, rubbed against the flange of the wheels and checked the wagon in that way. Now there comes from America a description of an arrangement of this sort, which has been fixed at the Gibson yard of the Indiana Harbour Belt Railroad. Nothing is said in the description as to the idea having come from Germany. Anyway, the two inventions are very much akin to the tub retarder for collieries provided by the Westinghouse Brake and Saxby Signal Company, which was illustrated on page 126 of our issue of August 1st.

The Smithfield Club Show.

LAST year the engineering exhibits at the Smithfield Club Cattle Show showed so little originality that we passed them over very lightly. This year, however, the Show opened at the Agricultural Hall, Islington—it closes, by the way, to-day, December 12th—with several new machines for review, and we thus gladly resume below our old custom of describing some of the more interesting items on the stands.

One of the most novel exhibits at the Show is the portable engine shown on the stand of the Sentinel Wagon Works, of Shrewsbury, which is illustrated by Fig. 1. It is really built up of the boiler and half the engine used on the Super-Sentinel steam wagon, which has already been described in THE ENGINEER. That is to say, the engine has only one cylinder, instead of two, as is the case with the wagon. The two units are mounted on a channel steel frame, carried by wheels, and the whole machine is so light that it can be drawn by one horse. It is, in fact, this feature of lightness which is the outstanding merit of the engine, as it weighs less than half as much as the ordinary "portable."

The engine has a cylinder 6½in. in bore by 9in. stroke, and runs at any speed from 250 to 400 revolutions per minute. It is fitted with a governor of the Pickering type, driven off the crank shaft by means of a belt. The two pulleys, or fly-wheels, are 2ft. 9in. in diameter by 6in. and 8½in. wide. The lubrication is entirely automatic, and is effected by a positively driven pump and a large sump in the crank case. The boiler is of the quick-steaming multitubular type, and is fitted with an extra large brick-lined fire-box to enable it to burn low-grade fuels. It is capable of evaporating over 9 lb. of water, at 500 deg. Fah., per pound of good coal. The makers say that the engine will deliver 44 brake horse-power when fired with good Welsh steam coal, or 35 horse-power with moderate fuel, while they guarantee that it will give 20 brake horse-power on anything that will burn. The fuel consumption with good steam coal is put at 3 lb. per horse-power hour, or with average moderately dry wood containing, say, from 25 to 30 per cent. of moisture, from 9 lb. to 10 lb. per horse-power hour. The engine is also made with two cylinders, but otherwise the same, and it then has a correspondingly increased power output.

The steam wagon shown in Fig. 2 is a new type, which is being built by Fodens, Limited, of Sandbach, and is fitted with a three-way tipping body. The tipping is effected by means of a hydraulic ram supplied with water by the feed pump on the engine. There is, of course, a three-way cock in the feed pipe, so that the pump can be used for either purpose. The wagon is capable of carrying a load of 6 tons at from 12 to 14 miles per hour, or 10 tons with a trailer at about 8 miles per hour, and will ascend a gradient of 1 in 7. The platform is 11ft. long by 6ft. 6in. wide. The boiler is of the usual locomotive type, and has a total of 90 square feet of heating surface. The engine is compounded, and has steam-jacketed cylinders, 4½in. and 7in. in bore by 7in. stroke. Power is transmitted to the rear axle, which has a bevel gear differential, by means of a 2½in. pitch roller chain. There is a band brake on the rear axle, besides brakes working inside the rims of both driving wheels. The wagon exhibited has Ackerman steering gear, but it can be fitted with a plain front axle and chain steering gear if required. The water tank has sufficient capacity to take the wagon over a distance of 30 miles.

On the stand of J. and H. McLaren, of Leeds, there is the oil engine-driven ploughing windlass which we have already described in connection with previous Shows at the Agricultural Hall, and which is now fitted with interlocking gear, so that the driver cannot accidentally wind the plough up into the windlass when he has put the travelling gear in operation, and naturally has his attention distracted from the plough. The engine is nominally of 60 horse-power at 850 revolutions per minute, but will give 65 horse-power at 950 revolutions, and by being speeded up to 1050 revolutions will develop 70 horse-power. On the same stand there is an eleven-tine cultivator, capable of working to a depth of 18in., suitable for operation in conjunction with the motor windlass. This implement weighs several tons, and as a consequence it is necessary to check its fall when the tines are lowered to their work. For this purpose the lowering gear is equipped with an oil dashpot, which is so arranged that the gland is not under pressure, and leakage is consequently reduced to a minimum. There is a chain connection between the draw gear and the cranked axle, so arranged that the tines are automatically lifted out of the ground as the implement is turned round at the headlands.

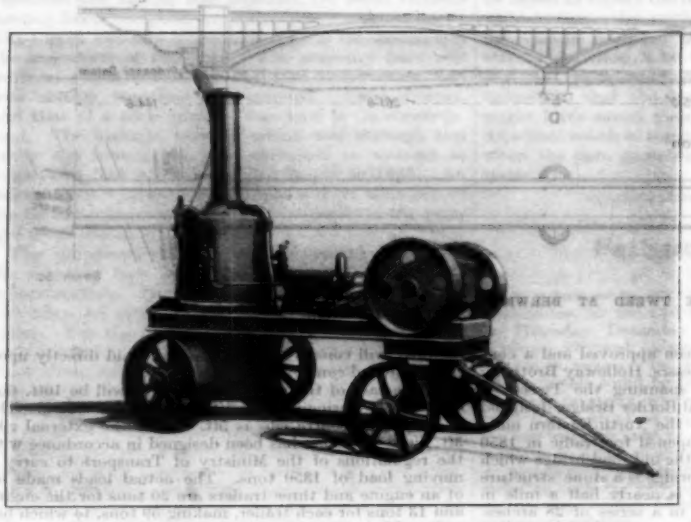


FIG. 1—PORTABLE ENGINE—SENTINEL

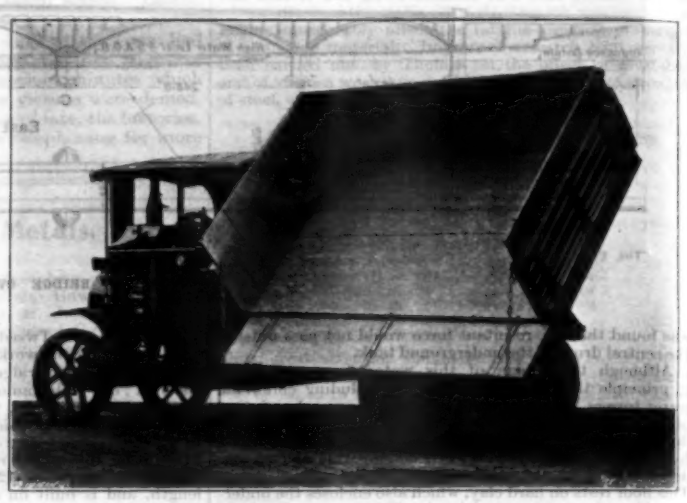


FIG. 2—THREE-WAY TIPPING STEAM WAGON—FODENS

Among the larger exhibits on the stand of Messrs. Tangye, Birmingham, there is nothing very novel, but there is a little single-ram pump, which is remarkable for its low price, considering the quality of the workmanship put into it. It is made in three sizes—3¼in. by 3in., 4¼in. by 4in., and 5¼in. by 5in.—all intended to run at 90 revolutions per minute and to work up to 150ft. head. The ram is of cast iron, working in a cast iron gland, and the valves are of india-rubber with brass guards. Air vessels are provided on both the suction and delivery sides of the pump, and the crank shaft bearings have been specially designed to prevent oil creeping on to the pump body. Our readers are so familiar with the features of this firm's cold-starting heavy oil engine that it needs no description here.

The steam tractor illustrated by Fig. 3 is being shown by John Fowler and Co., of Leeds, and has been specially designed to comply with the new regulations of the Light Locomotives Act, which allow an unladen weight of 7¼ tons. It is, it will be seen, fitted with rubber-tired wheels, and can be converted into a road roller by two men in two hours, without the aid of any special lifting gear, except screw jacks. For this purpose the fore-wheel carriage is mounted on a hinged bracket, which pivots on the smoke-box and can be swung up to accommodate the front roller. In this position the bracket is bolted to an angle iron fixed on the top of the smoke-box. The makers inform us that the tare weight of this tractor and its trailer is no greater than that of a corresponding steam wagon and trailer.

One usually expects to find something new on the stand of Drummond Brothers, of Guildford, and there is no disappointment on this occasion, for the company is showing the little force pump illustrated by Fig. 4. As will be noticed, there are several peculiarities about the design. The two crank pins are, for instance, greatly enlarged, so that they practically become excentrics, and the excentric straps are in one piece, with a cover plate on the outside to keep them in place. The glands round the rams are usually deep and act as guides, instead of the rams fitting in the barrels, so that liability to jam, through the glands being pulled down unequally, is minimised. The valves are rubber balls with hard cores. The pump will suck from a depth of 20ft., and will deliver 1000 gallons of water an hour, against a head of 100ft., when the belt pulley is running at 200 revolutions per minute. The rams are 4in. in diameter by 3in. stroke, and the overall dimensions of the pump are 32in. by 19in. by 24in. The weight is just over 2 cwt.

Richard Garrett and Sons show a thrashing machine, a tractor and the steam wagon which we have already described. The wagon exhibited has an ordinary body, but, in conversation with the firm's representative, we learned that one of the latest applications of the chassis is the transport of bituminous road metal in the hot condition. The wagon is then fitted up with a double-shelled, cylindrical container, with a large filling door on the top and a discharge opening at the rear. The tank is tilted hydraulically for emptying. Pipe connections are made between the boiler and the space separating the two shells of the container, so that steam can be supplied for heating the contents. An ejector is provided for creating a partial vacuum in the space and thus reducing the loss of heat from the load.

Ransomes, Sims and Jefferies, of Ipswich, show their familiar galleried stand with a number of agri-

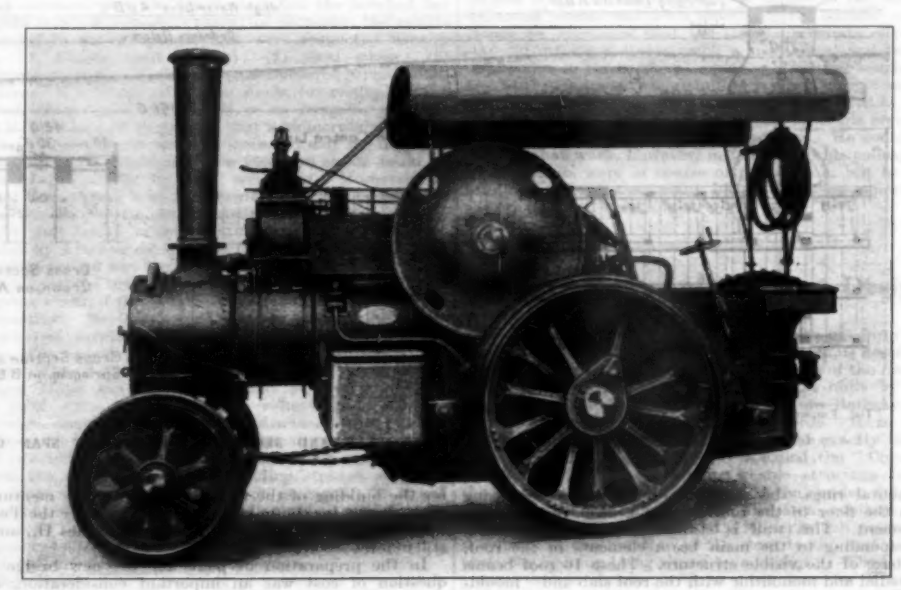


FIG. 3—SEVEN AND A-HALF TON STEAM TRACTOR—FOWLER

cultural implements, including a new apparatus known as a "grass rejuvenator," a 6 nominal horse-power compound traction engine, and a 4 brake horse-power oil engine. The traction engine, thrashing machine and oil engines on the stand of Marshall, Sons and Co., of Gainsborough, have all been described in our columns, while Petter's oil engines need no further description. Most of the old *habitués*—such as William Allchin, of Northampton; Aveling and Porter, of Rochester; Blackstone and Co., Stamford; Chas. Burrell and Sons; Clayton and Shuttleworth; Wm. Foster and Co.; Ruston and Hornsby; W. Tasker and Sons; and Wallis and Steevens—all have stands at the Show, but their exhibits are so very much like those shown on previous occasions that we will not weary our readers by enlarging upon them again.

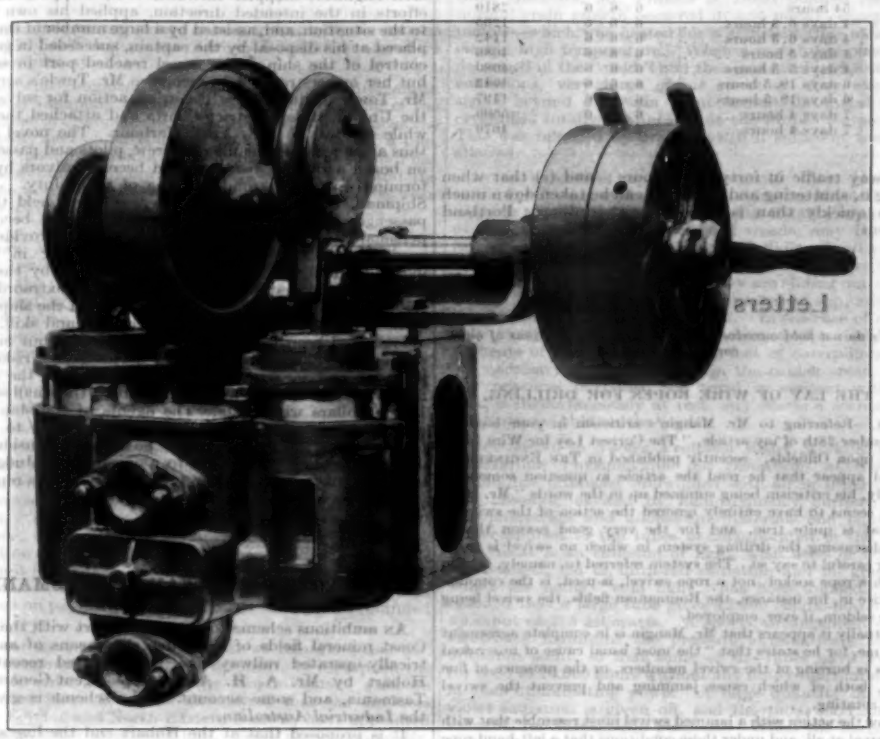


FIG. 4—FORCE PUMP—DRUMMOND BROTHERS.

A Pneumatic Plate Tightening Machine.

WE were recently afforded an opportunity of examining a new type of pneumatic tool which has been designed automatically to draw together metal sheets or plates prior to the operation of riveting them together. The machine is known as the Hollett pneumatic plate tightening machine, and an outside view of it is reproduced in the accompanying engraving—Fig. 1. A drawing—shown in Fig. 2—serves to illustrate the principle on which it works. It may be noted that the tool consists essentially of two opposed air-operated pistons, which travel in a pressed steel cylinder and work two sets of double toggle gear. The upper toggle seat is attached to the top end of a draw-bar which at its lower end carries an automatic air-controlled chuck, the purpose of which is to grip the bolt used for pulling the two plates together. At the bottom end of the draw-bar there is also a stand or foot piece, which is knurled on its outside diameter, and which, when turned on its screwed seating, serves to lengthen or shorten the stroke of the draw-bar. When air is admitted to the cylinder the two light steel pistons advance towards each other, and the toggles approach nearly a straight line, simultaneously moving the upper and lower toggle seats apart. The bolt, previously gripped by the chuck, is drawn up and the top plate on which the machine rests is forced down, bringing the two plates together in close contact ready for riveting. The type of bolt used differs from the ordinary threaded swivel bolt, and is shown in diagrammatic form in Fig. 2. It has a button head forming a slight shoulder, which gives a good gripping surface for the chuck, while the main shank is slightly tapered, the head of the bolt being furnished with a pan type rivet head. In the top part of the bolt a long slot is formed, into which is passed a tapered key. The key is driven into the slot and the bolt thus secured in position, while the pressure is maintained by the tightening machine. The key having been driven the machine may be released ready for the next bolt.

FIG. 1 PLATE TIGHTENING MACHINE

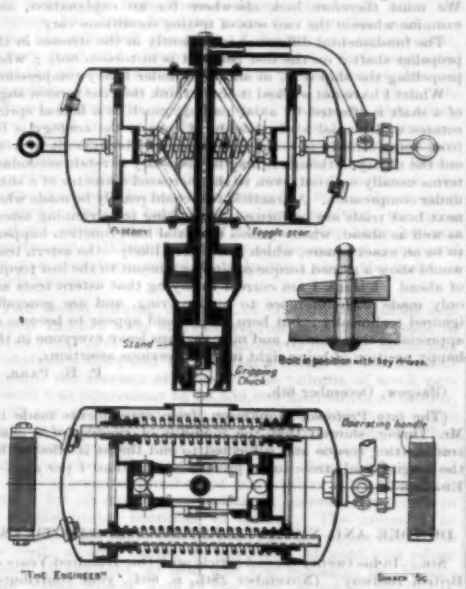


FIG. 2

The entire operation of the machine is governed by the handle shown at the right hand in Fig. 2. Assuming that the bolt already described has been placed through the two plates which it is desired to draw together, the machine is lifted by the operator and the chuck placed over the end of the bolt. A quarter turn of the control handle serves to close the jaws of the chuck on to the bolt head, after which the operator may, if desired, entirely release his hand from the machine. A further small turn admits air to the cylinder, and the plates are drawn tightly together. The taper key may now be driven into the slot and the machine released.

In order to release the machine the control handle is turned in the opposite direction, which allows the air to escape through the control valve and permits the two piston release springs to force apart the pistons and press down the chuck in the stand of the machine. A further movement of the handle releases the air pressure from the chuck and allows the machine to be disengaged from the bolt.

Air at 100 lb. per square inch is used to work the machine, and three sizes are employed to cover the range of work usually met with in shipyard, boiler, girder and bridge work. For the lighter work a 14½ lb. machine with 5in. cylinders is employed. This machine may be conveniently used for plates up to ⅝in. in thickness and with bolts of ¾in. to ⅞in. diameter, the closing pressure exerted being in the neighbourhood of 10,000 lb. In the case of heavier plates, say, up to ⅞in. thick, a 26 lb. machine with 6½in. cylinders is recommended. This may be used with ⅞in. and 1in. diameter bolts, and a closing pressure of about 20,000 lb. is exerted. For the heaviest work such as that on the turn of the bilges in shipyard work, a 36 lb. machine has been designed. It has a 7½in. diameter cylinder, and it may be used with 1in. and 1⅛in. bolts for plates up to 1in. in thickness, a closing pressure of about 30,000 lb. being exerted.

The makers claim that with ordinary delays, such as the time needed to place the plates in position, from 600 to 1000 bolts can be placed in position by one man and a lad working throughout an eight-hour shift.

The illustration—Fig. 3—shows the machine in use on the hull of a ship. The special bolts are fed from the inside of the hull by the boy working with the operator. Among other advantages claimed for the machine are the following:—Plates are tightly drawn together, which ensures more perfect riveting; the cost of labour is decreased, and the output increased, while there is a very material reduction in the cost of service bolts. When the tapered key is driven home, we are informed, it is not slacked off by the vibration of the riveting hammer. These bolts are drop forged and are made from a high carbon steel enabling them, we are informed, to be used many hundreds of times. In the case of the ordinary service bolt, continuous replacement becomes necessary, because the thread on the bolt is easily damaged, moreover time is wasted in unscrewing the nuts from the bolts, which is a tedious operation.

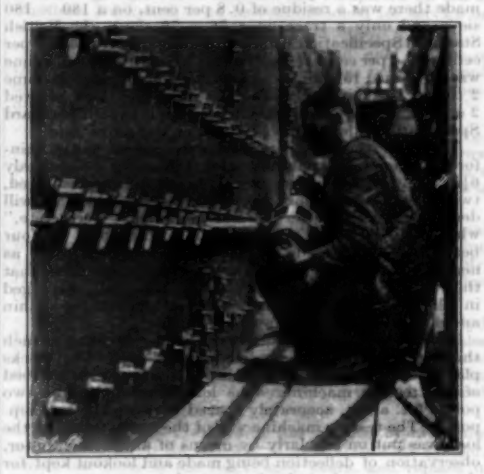


FIG. 3—PLATE TIGHTENING MACHINE IN USE

With a view to making the machine more useful for complicated shipyard, bridge and girder work, a specially designed cut-away stand is employed when working with rolled steel joists, which permits the machine to be worked quite close to the girder web. These specially narrow stands are made interchangeable with the other standard fittings, and equipment for every type of bolt or rivet may, we understand, be easily obtained from stock.

The machine is made by the Howard Pneumatic Engineering Company, Limited, of Eastbourne, for the Pneumatic Plate Tightener Sales Company, Limited, of Dashwood House, 9, New Broad-street, London, E.C. 2. This company acts as distributing agency for the British Isles and the whole of the world, excluding the United States. Considerable interest has been shown in the demonstration trials of this machine, which recently took place on the Clyde and the Tyne, and we understand that it has already been adopted for use in British shipyards.

"Ferrocrete"—A Rapid-Hardening Cement.

WE were asked to witness on Monday last some compression tests of beams made with a recently introduced rapid-hardening cement to which the name of "Ferrocrete" has been given. The invitation came from the Cement Marketing Company, Limited, of Portland House, Tothill-street, Westminster, S.W. 1, which company is the selling organisation of the Associated Portland Cement Manufacturers, Limited, the British Portland Cement Manufacturers, Limited, Martin, Earle and Co., Limited, and the Wouldham Cement Company, Limited. The tests were carried out in the laboratory of Professor S. M. Dixon in the Department of Civil Engineering of the City and Guilds Engineering College at South Kensington.

"Ferrocrete" is described as being a true Portland cement in the sense that no material enters into its composition other than those which are used in the manufacture of ordinary Portland cement; but, quite naturally, the makers prefer not to publish an analysis of its composition or to say what, if any, methods of manufacture differentiate it from the ordinary material of commerce. The tests which we witnessed, however, and other figures which have been arrived at as the results of tests carried out by Messrs. Riley, Harboard and Law, of 16, Victoria-street, Westminster, as well as the results of some tensile tests of a batch of "Ferrocrete" recently supplied to the Borough of Southwark, and made by the Cement Marketing Company, Limited, itself, show very clearly indeed that

the new cement differs very considerably from the old.

Taking first the company's own tensile tests, which were as follows :—

Tensile Strength (lb. per square inch).

Age.	Neat cement. Breaking load.	(3 parts standard) sand, 1 part cement. Breaking load.
24 hours	450	330
24 hours	460	350
48 hours	700	430
48 hours	750	450
3 days	800	500
3 days	860	540
7 days	900	630
7 days	940	650

It will be remembered that the British Standard Specification provides that the strength of a neat briquette at seven days must be not less than 450 lb. per square inch, whereas the "Ferrocrete" briquettes reach that strength after twenty-four hours and their breaking load rises to 900 lb. in seven days. Moreover, the B.S.S. stipulates that the strength of a standard sand briquette should be not less than 200 lb. per square inch at seven days, whereas the "Ferrocrete" briquettes averaged 340 lb. per square inch at the end of twenty-four hours and had an average strength of 640 lb. per square inch—more than three times the minimum specified figure—at seven days. We may add that of the sample on which the foregoing tests were made there was a residue of 0.8 per cent. on a 180 × 180 sieve and only a trace on a 76 × 76 sieve, the British Standard Specification stipulating for not more than 14 per cent. and 1 per cent. respectively. The initial setting time was 1 hour 15 minutes and the final setting time 2 hours 10 minutes. The Le Chatelier test showed 2 mm. at twenty-four hours, whereas the British Standard Specification allows up to 10 mm. at the same time.

The tests which we witnessed were carried out on reinforced concrete beams measuring 10ft. long and roughly 6¼in. by 10¼in. in cross section. We saw four beams tested, two made with ordinary Portland cement, which we will designate by the letter A, and two with "Ferrocrete," which we will call B. We were informed that all the four beams had been made by the same workmen, were as nearly identical in size and manufacture as possible, that the reinforcement was identical and identically arranged in all cases, and that the ages were all the same to within an hour or two, namely, fourteen days.

The beams were supported on blocks of wood, which themselves rested on rounded wedge-shaped steel blocks placed accurately 15ft. apart in all four cases on the bed of the testing machine. The load was applied at two points 5ft. apart, accurately spaced between the two supports. The testing machine was of the screw type and the load was put on regularly by means of an electric motor, observation of deflection being made and lookout kept for the appearance of cracks during each test.

The results which we witnessed were as follows :—

Beam.	Age.	Crushing load in lb.
A7	14 days	12,140
A8	14 days	12,760
B7	14 days	24,560
B8	14 days	24,240

It will be observed that the crushing load of the B ("Ferrocrete") beams was practically double that of the A (ordinary Portland cement) beams.

As a matter of interest we give in Table I. the results of tests of similar beams, but of less age, which were carried out in the same machine in the same laboratory on immediately preceding days. For the sake of comparison we have repeated at the bottom the results of the tests which we witnessed.

Table I.—*Compression Tests on Reinforced Concrete Beams.*

All "A" numbers made with ordinary Portland cement.
All "B" numbers made with rapid-hardening Ferrocrete.

No.	Age.	Dimensions. Width	Depth.	Weight in lb.	1st tens'n crack.	1st comp'n crack.	Max. load in lb.
		in.	in.				
A1	53 h. 30 m.	6.19	10.58	1,292	3,470	3,700	3,700
A2	54 h.	6.26	10.50	1,281	3,880	4,130	4,130
B1	52 h. 15 m.	6.05	10.50	1,283	7,240	13,970	13,970
B2	53 h. 17 m.	6.2	10.51	1,291	5,630	14,380	14,990
A3	4 d. 4 h.	6.12	10.50	1,269	4,280	6,250	6,350
A4	4 d. 4.25 h.	6.23	10.55	1,281	4,380	6,730	6,860
B3	4 d. 3.30 h.	6.19	10.58	1,291	4,600	15,580	19,680
B4	4 d. 4.15 h.	6.11	10.55	1,270	3,980	18,550	18,600
A5	6 d. 23.25 h.	6.16	10.59	1,270	4,440	9,260	9,260
A6	7 d.	6.24	10.64	1,285	4,575	7,415	7,415
B5	7 d. 3 h.	6.16	10.55	1,285	5,420	18,170	20,900
B6	7 d. 3.45 h.	6.36	10.64	1,282	4,065	22,195	22,545
A7	14 d. approx.	—	—	—	—	—	12,140
A8	14 d. approx.	—	—	—	—	—	12,760
B7	14 d. approx.	—	—	—	—	—	24,560
B8	14 d. approx.	—	—	—	—	—	24,240

It will be noticed that at all ages the "Ferrocrete" beams required a much greater load before they gave than did the ordinary beams, but that the relative difference between the breaking loads of the two kinds of beams became less as the age increased. Thus, whereas the mean of the breaking loads of the "Ferrocrete" beams at about fifty hours was 3.699 times greater than the mean of the breaking loads of the ordinary concrete beams, at fourteen days the mean of the breaking loads of the former was only 1.957 times as great as the mean of the breaking loads of the latter. It would be of interest to see what happened with beams of still greater ages.

In Table II. we reproduce the results obtained in crushing tests of concrete cubes at the same laboratory. These results, we may say, are, as regards the "Ferrocrete" blocks, very similar to those of tests carried out by Messrs. Riley, Harboard and Law. In this case, though the "Ferrocrete" blocks show their superiority at every stage, there is such a palpable discrepancy between the four and seven-day results with ordinary cement cubes that accurate comparison appears to be impossible.

The principal claims made for "Ferrocrete" are (*a*) that it develops the same strength in twenty-four hours as is required in the British Standard Specification at twenty-eight days ; (*b*) that it hardens sufficiently to bear roadway traffic in forty-eight hours ; and (*c*) that when using it, shuttering and centering can be taken down much more quickly than is possible with ordinary Portland cement.

Table II.—*Compression Tests on Cubes.*

All "A" numbers made with ordinary Portland cement.
All "B" numbers made with rapid-hardening Ferrocrete.

No.	Age.	Dimensions. Inches.	Max. load. Lb. per sq. in.
A1	56 hours	6×6×6	608
A2	56 hours	6×6×6	695
B1	54 hours	6×6×6	2460
B2	54 hours	6×6×6	2810
A3	4 days 6.8 hours	6×6×6	1265
A4	4 days 6.3 hours	6×6×6	1142
B3	4 days 5 hours	6×6×6	4086
B4	4 days 5.3 hours	6×6×6	4080
A5	6 days 19.5 hours	6×6×6	1043
A6	6 days 19.5 hours	6×6×6	1197
B5	7 days 4 hours	6×6×6	5000
B6	7 days 4 hours	6×6×6	4670

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE LAY OF WIRE ROPES FOR DRILLING.

Sir,—Referring to Mr. Mangin's criticism in your issue of November 28th of my article, "The Correct Lay for Wire Lines Used upon Oilfields," recently published in The Engineer, it would appear that he read the article in question somewhat hastily, his criticism being summed up in the words "Mr. Hayward seems to have entirely ignored the action of the swivel."

That is quite true, and for the very good reason that I was discussing the drilling system in which no swivel is used, being careful to say so. The system referred to, namely, that in which a rope socket, not a rope swivel, is used, is the common practice in, for instance, the Roumanian fields, the swivel being there seldom, if ever, employed.

Actually it appears that Mr. Mangin is in complete agreement with me, for he states that "the most usual cause of unscrewed joints is burring of the swivel members, or the presence of fine sand, both of which cause jamming and prevent the swivel from rotating. . . ."

Now the action with a jammed swivel must resemble that with no swivel at all, and under these conditions that a left-hand rope would tend to unscrew right-hand joints, was in fact exactly what I wished to demonstrate.

Again, your correspondent mentions in the last paragraph of his letter that a right-hand bailing line will sometimes unscrew a left-hand joint. Although the conditions are not quite similar, this evidence supports my contention that a left-hand rope will tend to unscrew a right-hand joint, and is not a paradox, as Mr. Mangin would have us believe. J. T. Hayward.

Ploesti, November 3rd.

LOST TORQUE IN MARINE ENGINES.

Sir,—Differences of 20 per cent. and more cannot reasonably be attributed to errors in modern instruments, each, of their type, of the best design and construction ; nor can the mere moving of an engine from the shore to its bed in a steamship be imagined to reduce its efficiency to any appreciable extent. We must therefore look elsewhere for an explanation, and examine wherein the two sets of testing conditions vary.

The fundamental difference is evidently in the stresses in the propeller shaft ; on the test bench it is in torsion only ; when propelling the ship it is, in addition, under heavy compression.

Whilst I have not worked it out, I think that the torsion angle of a shaft is affected by axial loading, much as a helical spring rotates under axial load, though, of course, the analogy is far from being strictly in order. It should not be difficult to work out the theory, although it may be necessary to retain secondary terms usually omitted, even to the increased diameter of a shaft under compression. A practical test could readily be made when next boat trials are performed, by making tests running astern as well as ahead, when—unless the axial load function happens to be an exact square, which is not very likely—the astern tests would show a gained torque of similar amount to the lost torque of ahead. I think I am correct in saying that astern tests are only made with reference to manœuvring, and are generally ignored technically ; but here they would appear to become of appreciable importance, and may perhaps leave everyone in the happy position of being right in their previous assertions.

P. H. Parr.

Glasgow, December 6th.

[The late Professor Hopkinson, from experiments made by Mr. Thring, showed that the modulus of rigidity of a shaft transmitting torque and subjected to end thrust is affected by the longitudinal stress to no greater extent than 1 per cent.—Ed. The E.]

DUNDEE AND NEWTYLE RAILWAY LOCOMOTIVES.

Sir,—In his twenty-second article on "One Hundred Years of British Railway" (November 28th, p. 604), your contributor states that three 0–2–4 locomotives of the "Earl of Airlie" type were built by Messrs. Carmichael and Co. for the above-mentioned railway, *i.e.*, two in 1833 and one in 1834, the other engine being the Lord Wharncliffe and the third the Trotter.

I had a note to the same effect in one of my reference books, but, wishing to confirm the matter one way or the other, as I had seen statements suggesting that merely two locomotives in all were turned out by Messrs. Carmichael, I wrote to that firm last year, asking them if they could give me any information on the point. In their reply they remarked : "You may take it from us that there were only two locomotives built, namely, the Lord Wharncliffe and the Earl of Airlie, as all records go to prove this." F. W. Brewer.

Stevenage, December 8th.

SIXTY YEARS AGO.

In September, 1861, the Great Eastern steamship, two days out from Liverpool on her way to New York, encountered a violent gale, in the midst of which her rudder post was twisted off. For two days she floundered at the mercy of the waves, what time her officers sought to rig her with a temporary steering apparatus. The situation was an anxious one and might at short notice have become critical, but all the efforts of the officers and crew were of no avail to repair the damage. At last, when apparently some drastic step was about to be taken, one of the passengers, Mr. Hamilton E. Towle, an American civil engineer, stepped forward, and, stopping further efforts in the intended direction, applied his own ideas to the situation, and, assisted by a large number of the crew placed at his disposal by the captain, succeeded in getting control of the ship. The vessel reached port in safety, but her owners refused to recognise Mr. Towle's services. Mr. Towle in due course began an action for salvage in the United States District Courts and attached the ship while she was in New York Harbour. The novel point thus arose whether the officers, crew, pilots and passengers on board a ship in distress could become salvors by performing services beyond the line of their duty. Judge Shipman, before whom the case was tried, held that a passenger could become a salvor without first becoming personally disconnected from the vessel, provided he rendered services beyond those of assisting in working and pumping the ship imposed on him by the law. The judge held that Mr. Towle had rendered extraordinary services of this description and had rescued the ship from great peril by his own ingenuity, courage and skill. His labours had been protracted and exhausting, but in view of the fact that he had supplied no materials, risked no property and incurred little personal danger, the judge fixed the amount to be awarded to him at the small sum of 15,000 dollars with costs. The agents of the ship were obliged to give bonds before she was allowed to leave the harbour. There seems to have been considerable delay in bringing the action to a conclusion. Judgment in it was given on November 12th, 1864, and was reported in our issue of December 16th of that year.

AN ELECTRIC RAILWAY FOR TASMANIA.

An ambitious scheme to connect Hobart with the West Coast mineral fields of Tasmania, by means of an electrically-operated railway line, was outlined recently in Hobart by Mr. A. H. Ashbolt, ex-Agent-General for Tasmania, and some account of the scheme is given in the *Industrial Australian*.

It is proposed that at the Hobart end the line should start from Glenora or thereabouts, and the western terminus would be at Rosebery. This would be in the very heart of the potential mineral region of the West Coast and in the very spot where the most important part of the development of the future would take place in regard to the progress of the great zinc-lead sulphide branch of the mining industry of Tasmania.

The capital necessary, said Mr. Ashbolt, was to be found approximately in the proportion of one-half by the Trade Facilities Board of Great Britain and the balance by Armstrong, Whitworth and Co., of London, and by the Government of Tasmania. It was not known what would be the precise amount of capital required, but it was estimated at about £1,000,000. An essential to the flotation of the new company and to the establishment of the industry which it was proposed to create, would be an arrangement with the Electrolytic Zinc Company of Australia, Limited, to freight all the ores and concentrates produced by that company from its western mines.

It is proposed that the passenger traffic on the railway should be conducted in the daytime and the heavy mineral traffic during the night. The proposed railway would, when constructed, be 140 miles in length, and the running time for the trip to the West Coast would be approximately six hours.

An exhibition of hydraulic power is to be held at Grenoble from May to October next year, under the official patronage of the French Government. Its general aim will be to show the great progress made during recent years in the use of hydraulic power, not only in the production and distribution of electricity, but in its adaptation to the needs of modern domestic life and transport. Copies of the general syllabus may be had on application to the Exhibition and Fairs Division, Department of Overseas Trade, 35, Old Queen-street, S.W. 1.

The Railway Department reports on three accidents have recently been issued. On that at Canfield-place on August 31st, which was the subject of a note on our Journal page of September 5th, Colonel Pringle puts the blame upon the driver of the second passenger train, in that, after having been stopped at an automatic signal, he did not work to the rule, which says that he must "proceed with great caution, to the next signal ahead, keeping a sharp look-out and running at such a speed as will enable him to stop short of any obstruction that may exist." Colonel Pringle suggests a modification of the rule, so as to limit the speed to 5 miles per hour. The collision near London Bridge on September 13th (mentioned in this column on the 26th idem.) was, in the opinion of Lieut.-Colonel Mount, due to the driver of the light engine concerned taking signals, lowered for a train from Dover, as applicable to himself, and overlooking his own signals, which were against him. The fact that no recommendation is made in the report is, in one respect, significant, seeing that it could be claimed that automatic train control might have averted the collision. In our issue of September 26th mention was also made of a buffer stop collision the previous Friday on the London, Midland and Scottish side of London-road Station, Manchester. It was, Major Hall considers, due to unsuitable speed when running down the platform. The report in this case recommends a better type of buffer stop.

Railway Matters.

A LINE, 6 miles in length, is being built by the London and North-Eastern Railway from a point one mile south of Tickhill Station on the South Yorkshire Joint Railway to Firbeck Colliery. The works will include the excavation and removal of 360,000 cubic yards and the erection of four underbridges and five overbridges.

DEPRESSED trade conditions in South Wales led to a recent dismissal or reduction in grade of a large number of Great Western men. The company has promised the National Union that action shall be suspended for a month; that the superintendents of the other divisions on the system shall accommodate as many South Wales men as possible; and that no new men shall be put on anywhere for the present.

THE chief engineer of the Paris-Lyons-Mediterranean Railway Company, speaking recently at a meeting of the Chamber of Commerce of St. Etienne, announced that the company had under consideration the creation of a line, which, passing through a tunnel beneath the Mont Pilat heights, would link up the valleys of the Loire and the Rhone, and would thus shorten the distance by rail between Paris and Marseilles.

IT is expected that the service on the new electric railway Meester Cornelis-Tandjong Priok, Netherlands East Indies, will be inaugurated before the end of the year; the Oebroeg hydro-electric installation, which has harnessed the Tjitjatih River—where a maximum of 70,000 horse-power will be generated—is now nearly completed. Another big electrification scheme under consideration is that of the line Womokromo-Bangil. The current will be supplied by the Kali Konto hydro-electric installation to be erected within a period of from three to four years.

A VERY interesting case, which turned on the liabilities for accidents to the users of workmen's tickets, came recently before the Lord Chief Justice. The user was one of the sufferers in the Milton Range, Gravesend, accident of August 21st, 1922, but did not himself pay for his ticket. The man was employed on a contract for the Ministry of Health, and obtained the ticket by the presentation of a voucher. Had he been the direct purchaser the limit for damage, under a workmen's ticket, was £100. The man was awarded £1800, but a stay of execution was granted on payment of £200, which was not to be refunded in any event.

IN our issue of August 22nd last we remarked that Mr. C. F. Bengough had intimated his desire to relinquish the office of chief engineer of the North-Eastern area on December 31st. It is now announced that the directors of the London and North-Eastern Railway have appointed Mr. John Miller to succeed him. Since the grouping, Mr. Miller has continued to act as chief engineer for the Great Eastern area. Owing to his removal to York, Mr. C. J. Brown will become chief engineer for the whole of the Southern area. Mr. Brown was the chief engineer for the Great Northern, and when the London and North-Eastern was formed he took over the Great Central from Mr. Harry Blundell; now he will have charge of the three systems that form the Southern area.

WE are officially informed that the directors of the London and North-Eastern Railway Company have made the following appointments, to date from January 1st, 1925:—Mr. J. Miller, to be Engineer, North-Eastern Area, York, in succession to Mr. C. F. Bengough, who will retire at the end of the present year; Mr. C. J. Brown, at present Engineer for the Great Northern and Great Central sections, to assume control of the engineering work of the Great Eastern section, in addition to his present duties, with the title of Engineer, Southern Area; Mr. F. G. Randall, Assistant Divisional Superintendent, Liverpool-street, to be appointed District Superintendent, Southern District, Great Eastern section, in succession to Mr. G. Keary, who will retire at December 31st.

THE Nidd Valley Light Railway is the property of the Bradford Corporation, and is used as a public railway by residents in the district and for other purposes. It having been suggested that the waters of the Gouthwaite compensation reservoir might be employed in generating electricity so that the line could be worked electrically, instead of by steam, the waterworks engineer, Mr. Lewis Mitchell, has looked into the matter. After exhaustive examination he finds that under the most economic conditions of lay-out the scheme would not be financially a sound proposition. The quantity of water delivered into the Nidd from the reservoir averages 61 million gallons a day, but the flow is extremely variable, ranging from 3 million gallons per minute during heavy floods to about 10 million gallons per day. Even when 20 million gallons per day were being sent down, not more than 120 horse-power could be developed, and, as the electrical energy that would be required sometimes for the traction of one train was not less than 350 horse-power, it follows that it would be necessary to augment the electricity supply by a steam or other generating station. The annual cost would be seven times the present steam-running expenses.

ACCORDING to the Board of Trade returns the value of the railway material exported during the first ten months of the present year was as follows, the corresponding figures for 1923 and 1922 being added in brackets:—Locomotives, £1,597,681 (£2,271,255, £4,287,033); rails, £1,382,674 (£2,068,568, £2,007,561); carriages, £982,108 (£834,389, £1,593,057); wagons, £2,839,188 (£2,622,210, £2,841,334); wheels and axles, £493,178 (£811,720, £1,032,056); tires and axles, £511,836 (£536,876, £356,777); chairs and metal sleepers, £1,042,222 (£799,973, £1,832,704); miscellaneous permanent way, £947,812 (£979,837, £1,184,275); total permanent way, £4,562,403 (£5,450,467, £6,657,196). The weight of the rails exported was 149,468 tons (230,619 tons, 210,166 tons), and of the chairs and metal sleepers, 83,402 tons (69,618 tons, 128,282 tons). During the month of October last locomotives of the values named were shipped to the following countries:—South Africa, £15,390; India, £9340; Europe, £7889; Australia, £4631; and certain unspecified countries, £68,073. Rails similarly were shipped as follows:—Argentine, £31,908; Chili, £15,926; Australia, £9377; India, £8833; New Zealand, £5883; West Africa, £2530.

Notes and Memoranda.

AN article, in the form of a diary, in the "Journal" of the Federation of British Industries, shows that it is now possible to travel from London to Peking *viâ* Siberia in sixteen days and at a cost of about £40. Going *viâ* Suez the time taken is approximately six weeks and the cost £100, while the New York route takes five weeks and costs at least £120, excluding meals and sleeping accommodation in America.

IN the course of a lecture to the Staffordshire Iron and Steel Institute, Mr. Francis S. Dodd pointed out that normal grain growth occurred in any metal—except cast metals—which was heated for a sufficient time at a sufficiently high temperature. When a metal was plastically deformed in the "cold" and then annealed under suitable conditions, very large grains resulted. Any excess of strain beyond a certain point caused the metal to recrystallise totally if annealed at the proper temperature. This was followed by grain growth if sufficient time was allowed.

IN an extensive paper on pneumatic tires, presented to the Institution of Automobile Engineers, Mr. A. Healey suggests that the reason for the smaller liability to skidding of tires with broken or patterned treads, may be found in the relation between rolling and sliding friction. As is well known, the coefficient of friction between two bodies at rest is far greater than when they are sliding one on the other. The plain tread tire is compelled to slip, and thus its coefficient of friction is reduced. In the case of a suitably designed broken tread, however, the individual elements of the tread act as the feet of caterpillars, and the necessary slip is taken up in the rubber tread itself. For practical purposes, the tread in contact with the road is instantaneously at rest, and exerts a correspondingly greater hold on the road.

ACCORDING to *Nature*, Professor Risler, working in the Laboratoire Physiologique des Sensations at the Sorbonne, has produced tubes filled with air or other gas at low pressure, excited by high-frequency current, with phosphorescent and fluorescent materials and pigments, either applied to the tubes or incorporated in the glass. The result is an emission of light, with little or no long wave-length red or infra-red radiation and no green, to which the name "cold light" has been applied. It is claimed that a large tube gives 12,000 candle-power with an input of 2.5 kilowatts. A special arrangement of the electrodes maintains the pressure automatically at the optimum point, so that some of the tubes have worked for 9000 to 10,000 hours without any noticeable diminution in their illuminating power. A large quantity of ultra-violet radiation is given off, and the tubes have proved valuable for therapeutic purposes. When the current is switched off, the tubes continue to glow with phosphorescent light, the colour of which is different from that emitted previously, and the tubes appear suitable for use in advertising.

IN the research laboratory of the General Electric Company of America, states the *Electrical Review*, apparatus has been made whereby a magnet, when brought near a piece of iron, causes a roaring noise to issue from a loud speaker. A piece of soft iron is inserted in a coil of 17,000 turns of three-mil wire. The coil is attached to an amplification set, which in turn is connected either to head 'phones or to a loud speaker. When a magnet is brought near the iron, a rustle is heard. If the approach is rapid, the noise is loud and abrupt; if slow, the sound is softer and lasts longer. While the magnet is being removed, a similar sound is heard. If the magnet is quickly removed and quickly brought back to its former position, only a little sound is heard. If it is brought still nearer the iron, there is more sound. If, after the magnet has been brought near the iron bar and the noise has subsided, the poles of the magnet are reversed, a very loud and abrupt noise is heard. It is suggested that the phenomenon results from the motion of the unit magnetic particles within the iron. Thus, when the magnet is brought near the iron, groups of the atoms turn round to face in the same direction. The stronger the magnetic influence the larger the number of particles that turn round, the greater the effect, and the louder the noise. Similarly, when the magnet is removed, the atoms gradually become disarranged. When the magnet is quickly brought back to its original position, the noise is slight since only a few of the particles have become disarranged. When the polarity of the magnet is reversed the particles turn round quickly, and thus the noise is much louder.

THE metal mining industry of the United States employed 123,279 men in 1923, representing an increase of 17 per cent. over the number employed in 1922, according to statistics compiled by the Department of the Interior through the Bureau of Mines. The volume of work performed was equivalent to 36,559,805 men-shifts of labour, or 25 per cent. more than in the preceding year. The death-rate from accidents at the mines was lower than has ever been recorded, but the non-fatal injury rate continued to rise. The volume of work done, as indicated by the aggregate number of man-shifts of labour performed by all employees, indicated increased activity in all of the major branches of mining. The increase, as compared with 1922, was 37 per cent. at copper mines, 35 per cent. at iron mines, 11 per cent. at gold and silver mines, 19 per cent. at lead and zinc mines in the Mississippi Valley States, and 12 per cent. at mines producing non-metallic minerals. Not only did the industry as a whole enjoy greater activity than in the preceding year, but the average number of work days per man was 297 in 1923, as compared with 276 days in 1922. This increase was shown for all branches of mining. The main causes of fatal accidents underground were falls of rock from roof or side, haulage, explosives, and falling down chutes, winzes, raises, or stopes. Of the non-fatal accidents the principal causes were falls of rock from roof or side, handling and loading ore at the face, haulage, timber, or hand tools, and drilling. In open-pit operations the main causes of fatal accidents were haulage, explosives, and falls of rock, while the non-fatal injuries were caused mainly by haulage, falls of rock, hand tools, falls of persons and steam shovels.

Miscellanea.

IT is proposed to put up a large beet sugar factory in the southern part of Alberta.

THE Borough Council of Worthing proposes to construct new waterworks at Long Furlong.

IT is reported from South Africa that the large graving dock nearing completion at Durban, which will be the second largest in the world, is to be opened next March.

ACCORDING to a letter of Mr. Neville Chamberlain, the Minister of Health, it appears to be unlikely that the Government will re-introduce the Smoke Abatement Bill until 1926.

THE total nominal capital of the 785 gas undertakings of Great Britain is £165,210,254, the receipts amounted last year to £67,576,358, and the expenditure was £56,593,900.

IT is reported that the Southern Railway Company is about to seek powers to secure additional land at Meldon, near Okehampton, for the extension of the large stone quarries already worked there.

THE new submarine L53, which was built by Sir W. G. Armstrong, Whitworth and Co., and completed for sea at Chatham Dockyard, is to be commissioned for service on the Mediterranean station on January 8th.

IT is expected that the value of the gold output of Ontario for the present year will be in the neighbourhood of 25,000,000 dollars. There are now eleven regular producers, compared with seven in October last year.

THE new motor omnibus service of the Glasgow Corporation Tramways Department between Monteith-row and Maryhill was begun on the 8th inst. The route is a little over 5 miles in length and a six minutes' service is maintained.

THE scheme for the construction of a longitudinal bridge down the centre of the Thames, between London and Blackfriars bridges, which was put forward by Mr. H. W. Abrahams, has been thrown out by the London County Council.

DURING the testing of a new pipe line from Cowlyd Lake to the Dolgarrog power station of the North Wales Power Company, the pipe burst last week, and some damage was done by the resultant flood of water. The electricity supply was not, however, greatly interfered with.

THE Chesterfield Corporation has decided by a narrow majority to scrap the existing electric tramways system, which has been in use for twenty years, and replace it with a trackless car service. It is said that the cost of putting the tramway in order would have been about £100,000, whilst the trackless car scheme will cost £39,000.

A CONTRACT has been signed, subject to approval of lawyers in London, whereby the Caribbean Transport Syndicate of London will construct first-class streets and install proper waterworks and tramway systems in Barranquilla, Colombia, the initial outlay being 2,500,000 dollars with a further option of spending another 7,000,000 dollars on other improvements.

THE Lichfield City Council has approved a scheme, which it is estimated will cost £39,040, for obtaining a bulk supply of electricity from Walsall Corporation, and an agreement has been prepared between the Council and the War Office to supply energy to Whittingdon Barracks. The Rural District Council has given its consent to the order applied for by the City Council authorising it to carry out the scheme.

THE new civic steam-heating plant at Winnipeg, Man., was formally opened on November 12th, and is in satisfactory operation, supplying 110 customers. Its erection and equipment occupied a little over twelve months, and its cost was approximately 1,000,000 dollars. Contracts already secured will provide a revenue of 200,000 dollars for the first year. A recent discovery that pulverised lignite mined locally can be satisfactorily used for the production of steam has been found an important factor in reducing operating costs.

IT is understood that the Dominion Government is putting up for sale practically all the pulp wood area in the Province of Manitoba, an immense tract of land, including more than 1100 townships, or 40,000 square miles. The purchaser, according to reports, is entitled to select within five years tracts containing not more than 3,000,000 cords of spruce pulp wood from within this area. The purchaser is required to start his selection within one year, and is to erect a pulp and paper mill costing not less than 2,000,000 dollars.

THE Government of Mysore has many projects in hand for the exploitation of the State's natural resources. The latest details regarding the Cauvery River irrigation scheme show that it is intended to irrigate 110,000 acres of land, which will be carried out by means of reservoirs on the Cauvery and its tributaries. The impounded water will be utilised also for power generating purposes. The Krishnaraja Sagara scheme would, it is understood, yield at least 4000 horse-power. Finally there is the important project at Gersoppa Falls, which the Durbar is now actively investigating.

THE Montreal Harbour Commission has decided to proceed with the construction of the new South Shore Bridge across the St. Lawrence at Montreal without delay. The work will be directed by a joint association of designing and consulting engineers composed of Messrs. Monserratt and Pratley and Joseph C. Strauss, assisted by an advisory board of five engineers, including Mr. T. W. Harvie, general manager of Montreal Harbour; Mr. G. Herrick Duggan, Mr. H. M. Mackay, Dean of the Faculty of Engineering at McGill University; Mr. E. J. Vallee, Chief Engineer of Roads and Works for Quebec; and Mr. H. A. Terrault, City Engineer, Montreal. All designs and plans as to the site and structure of the bridge will be submitted to these organisations, which will report upon them to the Commission, and, on the selection of a site, will undertake the necessary surveys and borings, supervise the drawing up of plans and specifications, and carry the work to completion.

THE "CHIMNEY" OR "DEVIL'S" CONDUIT-HEAD OF THE GREY FRIARS MONASTERY

(For description see page 658)

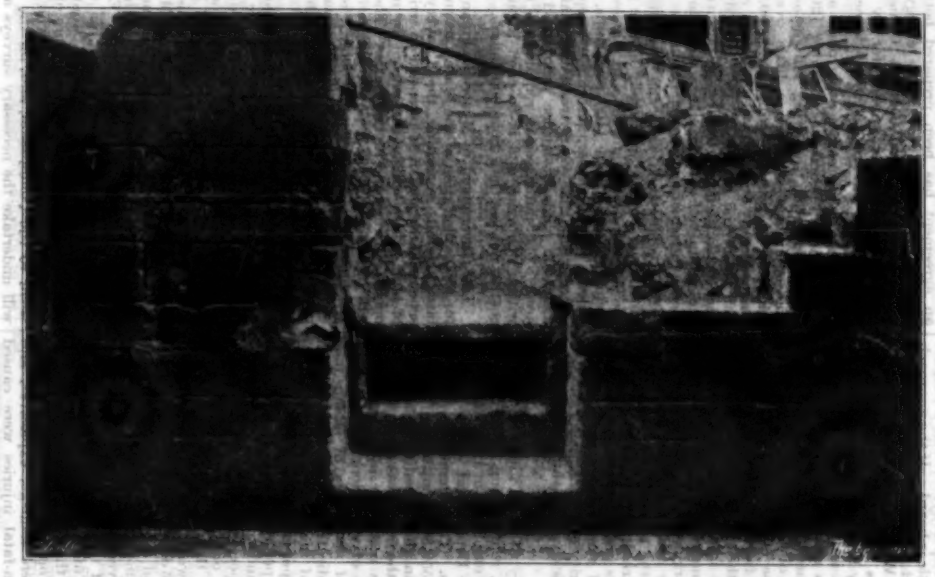


FIG. 5—FOOT OF STAIRCASE AFTER REMOVAL OF UPPER STEPS

FIG. 6—INTERIOR OF RESERVOIR AFTER REMOVAL OF VAULTING

FIG. 7—OPENINGS IN EAST WALL OF RESERVOIR

FIG. 8—PASSAGE DOWN TO RESERVOIR FROM NORTH-WEST, AND SILL OF WINDOW

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Half-yearly (including index number) .. £1 12s. 6d.
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DEATHS.

On December 6th, at 103, Inchmery-road, Catford, WALTER LANGDON-DAVIES, in his 58th year.

On December 1st, at 20, Woodchurch-road, West Hampstead FRANCIS JAMES PLATT, M.I. Mech. E., second son of the late James Platt, M. Inst. C.E., of Gloucester.

THE ENGINEER.

DECEMBER 12, 1924.

Creep in Metals Under Stress.

THE phenomenon of creep in metals under stress is not of recent discovery. It was noted by Fairbairn and discussed by Kelvin in the 'sixties of last century. During the war it was closely examined at the National Physical Laboratory in relationship with the suitability of certain steels for aero-engine valves. About the same time, or subsequently, it was studied by independent workers in this country, France and America. Yet long as the subject has engaged the attention of physicists and scientists, it is doubtful whether the practical engineer has so far properly appreciated its full and true significance. His failure to do so may have arisen from a belief, still apparently held by some, that the subject is one almost wholly of academic interest, or because he found it difficult readily to obtain authoritative information about it. Neither reason can now be tendered as an excuse for further neglect. On Friday of last week Professor Lea, of Sheffield University, a prominent worker for several years past on the subject, presented a paper covering in a clear and able manner most of the principal facts concerning the phenomenon which have so far been discovered. Certain of Professor Lea's statements and conclusions may be, and have been, subjected to considerable criticism, but such criticism, last Friday at all events, was of a quantitative rather than a qualitative character. No one was bold enough or foolish enough to challenge the existence of the phenomenon or to throw doubt on its practical importance. All accepted it, the physicists with comfortable detachment, the engineers with obvious disquietude. Critics, as we have said, there were, but the principal of them directed their efforts towards showing that Professor Lea had in general understated rather than exaggerated the magnitude and significance of the phenomenon.

The nature of creep and its magnitude in certain mild carbon and chrome-nickel steels can be gathered from the summary of Professor Lea's paper which we give elsewhere in this issue. Briefly stated, it is shown that the application of a load to a specimen of metal at elevated temperature produces an extension, which slowly increases with time and which eventually either becomes stationary or continues until the specimen fractures, according as the applied stress is below or above a definite limiting value. It can be said with certainty that the higher the temperature of the specimen, the lower is the limiting value of the stress at which the creep of the extension ceases to die out and becomes continuous. For the present, however, the precise relationship between the temperature and the associated limiting stress cannot be stated, although it is probable that the law, if there be one, will be found to involve some power of the ratio of the test temperature to the melting temperature of the metal. Neither is it possible as yet to determine with great precision the limiting stress corresponding to a given temperature, even for a particular specimen. Professor Lea's published results are based on relatively short time tests. In general, he contented himself with observing the nature of the creep over a period of a few hours or a few days. It appears highly probable that had he extended the period of his observations, he would, at least in some cases, have got different results, generally in the direction of locating the limiting stress at a lower level than that indicated by his short time tests. At the National Physical Laboratory some long time tests have been made. In one noteworthy instance the specimen under a constant load and at a constant temperature crept slowly for seventy-nine days, and then fractured; while in another creeping continued, without showing signs of dying out, for more than four and a-half months. Again, it is still impossible to say at what temperature the phenomenon of creep becomes a really important factor affecting the practical use of a metal. It is certainly important in mild steel at 750 deg. Fah. That material if tested in the ordinary way—that is, quickly,—at such a temperature, will indicate a strength only slightly less than its strength at average room temperature, say, round about 30 tons per square inch. But if tested slowly in order to give the creep full opportunity to develop, it will fall under a stress of 16 to 18 tons. It might take many days before the creep caused failure, but even the longest of test periods is a short interval in the life of a structure, boiler or machine. Obviously, in this instance a grave risk of disaster would be involved if design were based on the quick test strength. Unfortunately, we are not yet able to say at what temperature less than 750 deg. the gravity of the risk would disappear. Professor Lea has gone to the lower end of the scale, and has examined the influence of creep on the failure of mild steel at ordinary temperature. He finds that such creep as there is always dies out until the breaking stress as ordinarily defined is reached. Failure at that stress is caused by the creep becoming continuous and refusing to die out. The ordinary breaking stress is, in fact, to be regarded as the limiting creep stress corresponding to room temperature. The conclusion seems logical that, given sufficient time, the phenomenon of creeping must affect the determination of the true failing strength at all temperatures from the ordinary upwards, and that the usual increase of strength revealed by quick tests on metals at temperatures up to about 570 deg. Fah. may have no true existence, so far at least as the practical use of the metals is concerned.

It may be said, of course, that since design nowadays is frequently based on the elastic limit or the fatigue limit, and not upon the ultimate strength, this phenomenon of creep, as it affects the breaking stress, is of relatively little practical importance. This contention would appear to be fairly true as regards the fatigue limit. The lowness of the stress under which a metal fails by creeping at an elevated temperature is not reflected in the fatigue limit under equal plus and minus alternating stress. It would appear that rapid alternations of tension and compression have the effect of nullifying wholly or in large part the existence of creep. Almost it would seem that whatever creep is developed during the tensile portion of the cycle is wiped out by the succeeding compression, or, alternately, that neither portion is of sufficiently prolonged duration to permit any creep to develop. Certain it is that at elevated temperatures Professor Lea found it possible to apply to a specimen without fracturing it many million cycles of a stress far above the limiting creep stress, which if steadily applied would, at the temperature of the test, have caused the specimen to fail in a comparatively short time. As regards the elastic limit, however, the contention is not sound. The phenomenon of creep, if present, practically deprives the term elastic limit of any precise meaning. We have referred above to a 30-ton carbon steel, which at 750 deg. Fah. failed by creep at 16 to 18 tons. That steel showed a small temporary creep at a stress of 4 tons. If there is any creep at all, even though it ultimately dies out, the strain corresponding to the stress

causing the creep is multi-valued and indefinite, and cannot without qualification be said to be proportional to the stress. We must, therefore, when dealing with metals at elevated temperatures, modify the definition of elastic limit or agree to regard it as the highest stress that can be applied to the metal without causing the elongation to creep. In the case of the metal we have referred to, we would thus be led to place the elastic limit at some stress less than 4 tons per square inch. With a normal factor of safety, an attempt made to base design on the elastic limit would thus lead to a working stress of less than a ton for a steel having a normal strength of 30 tons. In view of the high temperature, it might, in the case of boilers, be held desirable to adopt such a low figure, but for certain other classes of work it is conceivable that it would be better to abandon the elastic limit and use as the working stress some figure which, although it resulted in a passing creep, did not cause the final amount of creep to exceed a safe degree. Whether any amount of creep, however small, can with safety be tolerated is a matter which at present cannot be pronounced upon. It is but one of the many aspects of this interesting subject which await farther investigation.

Locomotive Superheaters.

The two articles which appeared in our impressions of November 21st and 28th last, entitled "Locomotive Cylinder Performance," illustrate very clearly many points of interest relating to the steam action in the cylinders of locomotives. One of the features to which our attention is drawn is the marked pressure drop which occurs between the boiler and steam chests, and which is especially noticeable at the higher powers. This drop is seen to be very considerable, amounting to as much as 25 lb. per square inch in extreme cases, a figure which must indicate a somewhat serious loss of available boiler power. It would have been valuable if corresponding figures for saturated steam engines had been given. That there is a fall in pressure between the regulator and the steam chest in saturated engines is well known, but apparently it does not approach that experienced with superheater locomotives. This fall in pressure is, of course, due to the throttling action of the superheater elements, and appears to be unavoidable.

Recently we have examined an epitome of the test plant reports dealing with trials at Altoona of a new series of 2–10–0 type freight locomotives of the Pennsylvania Railway, which are equipped with a superheater of different design from those with which the two locomotives K 2 s a and E 6 s—dealt with in our article of November 21st—are fitted. The new form of superheater, instead of being arranged in a small number of enlarged flue tubes, through which each element makes four passes, is fitted in a much larger number of flues and makes a double pass in each of two; that is, each element makes a double pass down the length of two flues in succession. This arrangement allows for the provision of a greater superheating surface and a greater cross-sectional area through the elements. In the case in point, and for boilers otherwise of identical design, the superheating surface is increased by 67 per cent. and the cross section by 30 per cent. The length between the tube plates in all the engines is 19ft., and the cylinders are of the same dimensions, yet—and this is the point to observe—the pressure drop is equal in amount. Evidently increasing the area of the steam passages is not in itself sufficient to minimise the pressure drop, for in the case of these two types of locomotives, though one had for a given cylinder volume steam ways 30 per cent. greater than those of the other, the fact that the steam had further to travel in passing through a larger superheater apparently offset any advantage obtainable through the greater area of the steam passages available. Reverting now to the usual type of superheater, we find in general use a form of construction in which, though four passes are made in each of the large flue tubes, but two passes travel the whole distance, the arrangement being such that each element only returns about one-half of the flue length, so that there is, so to speak, a short leg in the tube, and, furthermore, a greater percentage of the entire element is in the hottest part of the flue. It would be interesting to see this usual type of superheater compared for superheat and pressure drop with a type making four complete passes, both having the same sectional area; for whilst it is probable that the former design is better than the early type having four complete passes from the point of view of pressure drop, it would be interesting to know how much benefit is obtained. So far we have looked at the effect of the superheater and considered its influence on the cylinder steam from the point of view of the initial pressure obtainable. Other things being the same, the mean effective forward pressure on the steam pistons depends not only on the initial pressure, but also on that of the exhaust, or the least back pressure. Compared with saturated steam, a study of the back pressure conditions brings out the very important fact that, in equal cylinders and on a power basis, superheated steam exhausts with practically one-half the least back pressure of saturated steam, which represents an important gain, and though it does not make up for the loss in the pressure at admission caused by the superheater elements, it certainly helps to minimise it. Yet another point, also bearing on the question of power development, may be mentioned, and that is that with the same cut-off in the same sized cylinders, the superheater engines give more power than the saturated engine because of the decrease in back pressure.

These factors would appear to counteract in a measure the fall in pressure which is caused by the throttling action of the elements, but that throttling still remains of some moment, if, as we have already said, the full available boiler power is desired. It is scarcely necessary to remark in passing that whilst power is lost, the steam consumption is not materially increased unless the cut-off has in consequence to be made excessively late. Exactly how to reduce the loss of power through the throttling effect of the superheater, at any rate materially, is, however, not clear. If we increase the cross-sectional area and the surface we hardly alter matters, and if, again, we increase the cross section and reduce the length of the elements, and hence their surface, we must, we presume, sacrifice temperatures, a course not likely to be adopted; in fact, it seems probable that still higher superheats will be asked for in the future. The fall in steam pressure with increasing power is evidently one of the characteristics of the superheater as we now know it, and is apparently inseparable from its use.

Literature.

Jane's Fighting Ships, 1924. Edited by Oscar Parkes and Francis E. McMurtrie. London: Sampson Low. 1924. Price 42s. net.

Judging from the mass of new material which appears in the latest edition of "Fighting Ships," the past year has been a period of marked activity in the world's navies. New ships of every type are on the stocks, and many existing craft have been reconstructed with a view to increasing their value for war. These changes have made necessary a careful revision of the whole volume, for *Jane* is nothing if not up to date. In the section occupied by the British Navy the modifications are of a minor nature, for the Fleet remains pretty much what it was twelve months ago, and the Admiralty has not yet released details of the battleships, cruisers, &c., which are being built under the post-war programme. Nevertheless, this section has been enriched by reproductions of a number of recent photographs, including a series of "end-on" views which facilitate the recognition of ships when seen from a position ahead or astern. Two remarkably clear photographs of the aircraft carrier Eagle depict the changes made in the appearance of that ship since she was first commissioned for service in 1920. The only other vessel of note which has joined the Fleet is the cruiser Frobisher. She was begun as far back as 1916, her completion being delayed for reasons of economy.

The growing importance of the French Navy is attested by the many new illustrations and plans which have been introduced into this section. France to-day has only six battleships of modern type, but it is evident that she intends to keep her small battle fleet in a high state of efficiency, for all the vessels have undergone extensive refit. In the Courbet, for example, the two forward funnels are now in one casing, and a heavy tripod foremast has been fitted, so that her appearance is completely changed, and she might easily be mistaken for a unit of the more powerful "Bretagne" class. Her sisters, Jean Bart and Paris, are also provided with tripods, while the first and second funnels are now very close together. With regard to the three "Bretagnes," the elevation of their big guns is reported to have been increased from 18 deg. to 23 deg., though the note to that effect is admittedly unofficial. Diagrams and drawings of the latest French cruisers are given. Two of these ships will displace 10,000 tons each; they are to be armed with eight 8in. guns, and are designed for a speed of 33 knots. The other three are of the 7880-ton "Duguay-Trouin" class, carrying the light armament of eight 6.1in. guns, but expected to reach the very high speed of 34.5 knots. These vessels appear to have no protective armour beyond thin gun shields and splinter-proof conning towers. In this section will be found plans and particulars of the powerful destroyers and numerous submarines now being built in France, where a vigorous effort is being made to restore the Navy to its former commanding position in European waters.

Next in importance on this side of the Atlantic is the Italian Fleet, which appears to be specialising in swift, well-armed destroyers, though the programme in hand includes two 10,000-ton cruisers and ten submarines. Furthermore, the battleship Dante Alighieri has been reconstructed. Japan is making steady progress with the modified building scheme which came into effect after the Washington Conference. Already she has, and will continue to have for some years, the largest number of fast modern cruisers to be found in any navy. A highly successful type appears to have been evolved in the "Kuma" class, designed in 1918, since no fewer than fourteen of these ships are listed as under construction or complete. The aircraft-carrier Hosho, now illustrated for the first time, follows generally the lines of H.M.S. Hermes, though her three diminutive funnels give the Japanese vessel quite a unique appearance. Another newcomer in this section is the cruiser Yubari; her extraordinary arrangement of funnels must be seen to be believed.

Those Americans who have been perturbed by recent sensational disclosures respecting the alleged weakness of their naval forces will doubtless find comfort in the splendid array of ships shown in this volume. So far as material is concerned, the United States Navy is still a factor to be reckoned with. Not until the Nelson and Rodney are completed shall we have anything to compare with its latest battleships, which form the subject of some very handsome illustrations. From the æsthetic point of view, these ships would be vastly improved if tripods of the British pattern replaced the ungainly cage masts, whose utility, by the way, is questioned by American naval officers of our acquaintance. All the ten cruisers of the "Omaha" class are now completed. Most of them have exceeded the designed speed of 33.7 knots, and although some points of the design may be open to criticism, these ships represent a homogeneous squadron unmatched in speed and fighting power. Of the secondary navies, that of Spain has the largest amount of new construction in hand. Every other fleet able to muster a few ships, however insignificant, is allotted its due share of space in the book.

As the paper this year is of a better quality, the photographic reproductions are unusually clear—a feature of prime importance in a work of this description. For the rest, we need only say that there is no falling-off in the high standard of accuracy and comprehensiveness which makes "Fighting Ships" an indispensable work of reference to every student of naval affairs. It is jointly edited by Dr. Oscar Parkes and Mr. F. E. McMurtrie, who are admirably qualified for the task which they continue to perform with signal success.

Motor Bodywork: The Design and Construction of Private, Commercial and Passenger Types. By Herbert J. Butler. London: W. R. Howell and Co. Price 56s.

This is Mr. Butler's second book on the subject of motor vehicle bodies, the first, entitled "Motor Bodies and Chassis," having been published as long ago as 1912. Great strides have been made in this branch of the industry during the past twelve years. Then the body maker was almost exclusively a woodworker, and the types of body available were much fewer than at the present time. The number of private cars upon the road was probably not a fourth of those now in use, and the public service vehicle was only in its infancy. The chassis is now more or less standardised, and the reliability of the motive mechanism in all the well-known makes of cars may be taken for granted. It behoves the body builders, therefore, to step in with improvements in their part of the car to induce owners to purchase new vehicles. Hence it is essential that the present-day designer should have original ideas, the artistic temperament, and a good knowledge of mechanical engineering.

In the early days of the self-propelled road vehicle the construction of bodies was entirely a matter for the carriage builder, who had little or no experience outside that of horse-drawn carriages. In those days wood was the only material used for this purpose, and the body designs followed very closely those employed for horse-drawn conveyances. High seats, large road wheels, and the total absence of protection against the weather were all conspicuous features which were only eradicated by the process of time. For a long while the coach builders, under the delusion that the motor was only a temporary craze rather than marking the opening of a new era in locomotion, treated the subject of body building in a somewhat off-hand manner, with the result that the firms which were responsible for the chassis or motive mechanism had to tackle the construction of the bodies also. Being engineers, and used to dealing chiefly with metals, it was not surprising that the use of timber was given up to a large extent. The earlier efforts of the engineers were naturally somewhat crude, but they showed some originality of thought, and gradually designs were evolved which got away from the features of the horse carriage. The coach builders' art was sub-

sequently reintroduced, and when combined with engineering methods of production, great progress was made.

In his book, the author discusses in much detail the characteristic features of the many varieties of body and gives attention to methods of production. Separate chapters are included on such items as cape hoods, wind screens and folding seats. Materials of construction, the drawing-office, body making, sheet metal working, mounting, and trimming have each their own chapters, and there are numerous excellent large-scale illustrations from photographs and drawings. In the commercial vehicle section there are chapters on platform lorries, box vans, tipping wagons, trailers, omnibuses, "taxi-cabs" and chars-à-bancs. There seems to be, however, one striking omission from the contents of this otherwise most comprehensive treatise. We refer to the most recent developments in connection with the construction of silent closed bodies of leather fabric. The last twelve months has witnessed the adoption of this class of body, known as the Weymann, by many of the most important makers, but we have looked in vain through all the sections of the book for some reference to fabric body construction. Perhaps the book was completed before that class of work had reached such important dimensions. In spite of this omission, everybody who is interested in the construction of motor vehicles will find all that he is likely to need in the way of information and suggestions, down to the smallest items of carriage furniture and fittings, in Mr. Butler's work.

Introduction to Theoretical Physics. By ARTHUR HAAS, Ph.D., Professor of Physics in the University of Vienna. Translated from the Third and Fourth German Editions by T. VERSCHOYLE, M.C., B.Sc., A.R.C.S. Vol. I. London: Constable and Co. Price one guinea net.

THE author of this volume seeks to bridge the gap between classical and modern physics, and to present both as parts of a single connected whole. This, the first volume, is concerned with the older work, and it is impossible to judge from it how far he will be able to overcome the great difficulties which such an ambitious scheme presents. So far he has treated only classical mechanics and electro-magnetism; of these, he gives a clear and concise account, shirking no difficulties and indulging in no eccentricities. Perhaps he is almost too consistently classical in his treatment of the laws of motion; but, though everyone who has attempted any part of his task will make some criticism in detail, everyone will also agree that the book is very good.

But in spite of its excellence, it will probably not attract engineers, even if they have leanings towards the pure science that underlies their art. For the author displays no sympathy with the practical mind. His exposition is purely deductive; he describes well all the chief experiments which are usually adduced in support of fundamental principles, but he is not interested in experiments as such, and has no thought of applications. Moreover, though he keeps faithfully his promise to set out fully all steps in the mathematical argument and to assume at the start only the most elementary knowledge, his consistent preference for vector over co-ordinate methods will prove a stumbling block to many. Doubtless, engineers, who use graphical methods so much, ought to be at home in the vector calculus, but—let psychologists explain it as they will—the simple fact is that they are not.

While therefore we would express deep admiration for Professor Haas' work, and would most readily admit that the fault lies with our readers rather than with him, we cannot conscientiously recommend most of them to seek in his pages an introduction to theoretical physics.

One Hundred Years of British Railways.

No. XXIV.*

PART III.—THE LATTER HALF CENTURY.

THE YEARS 1886–1900.

1886.—In view of the fact that we are mainly regarding the leading events in railway engineering, the first item of the history of the year 1886 that we would mention is that on January 9th the first load of coal passed through the Severn Tunnel. It was cut at Aberdare on the morning of that day, and was in Southampton in the evening. But it was not until December 1st following that the new tunnel and its approaches—from Pilning Junction on the east and Severn Tunnel Junction on the west—were brought into use for passenger traffic. Another noteworthy event in engineering was the opening, on February 1st, of the Mersey Railway.

Other openings of note were:—Killin Junction–Loch Tay, April 1st; Parkgate–West Kirby, April 19th; the alternative route, *viâ* Upper Mill, from Stalybridge to Diggle, May 1st; Halwell–Launceston, July 21st; Willoughby–Sutton-on-the-Sea, October 4th.

* No. XXIII. appeared December 5th.

The only serious accident of the year occurred on June 30th at Portadown when, in a derailment caused by the track being distorted by an abnormal temperature, six passengers lost their lives.

1887.—Neither in 1886 nor 1887 was there any public legislation regarding railways or local Acts of note. There was, again, only one serious accident, but it was the disastrous one at Hexthorpe on September 16th, when 25 passengers were killed. To cope with additional traffic in connection with races at Doncaster, the Manchester, Sheffield and Lincolnshire suspended the block system and protected the trains by hand signals. The driver of one of that company's trains ignored a red flag and ran into a Midland excursion train.

The outstanding event was the opening, on June 20th, of the new Tay Bridge. That structure is 10,527ft. long, carries a double line of railways, and its straight portion of 7397ft. lies parallel to the straight portion of the earlier bridge but 60ft. away from it.

Of the new lines and extensions brought into use there were:—King's Sutton–Chipping Norton, on April 6th; the Helston branch, May 9th; the first section—to Swinton—of the Pendleton–Hindley line, June 13th; Holt–Cromer, June 16th; the West Clare from Ennis to Miltown Malbay, July 2nd; Pinner–Rickmansworth, September 1st; Alnwick–Coldstream, September 5th; Meols Cop–Hillhouse Junction, Altcar, October 1st.

1888.—In many respects the year 1888 was eventful, but in no respect more so than by the passage of the Railway and Canal Traffic Act, 51 & 52 Vic., c. 25, which made the Railway and Canal Commission a permanent body, called for a revision of rates and their publication, and invested certain powers in the Board of Trade. An Act of the same session, under which, instead of under the Regulation of the Forces Act, 1871, the railways could have been controlled during the late war, was the National Defence Act, 51 & 52 Vic., c. 31. Among the local Acts were those giving powers to the London and North-Western and Lancashire and Yorkshire jointly to acquire the North Union and the Preston and Wyre, and to the Midland Great Western to absorb the Dublin and Meath and the Navan and Kingscourt.

The openings of the year included:—The Birkenhead Park branch of the Mersey, and thence on what became the Wirral, to Wallasey, on January 2nd, and forward to New Brighton on March 30th; from Hurst Green Junction to Edenbridge, January 2nd, and forward to Ashurst Junction, October 1st; Brockenhurst to Bournemouth direct, March 5th; Pendleton–Hindley, continued from Swinton to Atherton on July 1st, and completed on October 1st; Bodmin–Wadebridge, September 3rd; Barmill–Ardrossan, giving the Caledonian access to the latter port, and allowing for a fast steamship service to Belfast, on September 4th.

During the year the reconstruction, at a lower level, of the Tithebarn-street Station, Liverpool, and its re-naming as the Exchange Station, was completed. The rebuilding of the same company's—the Lancashire and Yorkshire—station in Blackburn and the Exchange Station, Bradford—jointly owned with the Great Northern—was also finished.

A "race to Edinburgh" took place in August. On June 1st the West Coast reduced its timing from Euston to Edinburgh to 9 hours, the same as from King's Cross by the East Coast. The Great Northern replied by reducing the timing to 8½ hours, and when the West Coast said it would do the same as from August 1st the East Coast went six minutes better. A truce was then called, but to the end of the month the timings remained at 7¾ hours for the East Coast and 8 hours for the West Coast. The East Coast signalised the end of the truce by making the journey in 7 hours 27 minutes, despite a wait of 26½ minutes for luncheon at York and delays at Selby and Ferryhill. Reference may be made to a leading article hereon in THE ENGINEER of August 30th, 1888.

On July 2nd the important north-west express service of the London and North-Western and Great Western jointly between Manchester, Liverpool and Birkenhead and Bristol and the West of England *viâ* the Severn Tunnel, was opened. It brought Liverpool and Bristol within 4 hours 50 minutes of each other instead of at least 6 hours by the Midland route.

A broken axle on the Manchester, Sheffield and Lincolnshire—one in a passenger vehicle at Hyde Junction on July 14th—caused five passengers to be killed, whilst two lost their lives at Hampton Wick on August 6th, when a light engine set back on the facing road in the dark and met a passenger train.

1889.—The worst accident on British railways, except that of May 22nd, 1915, at Quintinshill, occurred near Armagh, Great Northern of Ireland, on June 12th, 1889, when a train, carrying a Sunday-school excursion, mostly children, "stalled" on a rising gradient of 1 in 75. It was divided between the fifth and sixth vehicle to allow it to proceed in two portions, and in the engine setting back to get a start the rear portion was set in motion and could not be stopped. The runaway vehicles met another passenger train "head-on," and 80 passengers were killed. The train was equipped with the vacuum brake, but it was non-automatic, and the block system was not in operation. The disaster furnished the Board of Trade with the long-desired opportunity of securing legislation to make concentration and interlocking of points and signals, the employment of the block system, and the use of automatic continuous brakes compulsory, and that was done by the Regulation of Railways Act, 52 & 53 Vic., c. 57. In view of the present small number of casualties—about three fatal accidents a year—caused by coupling accidents, it is significant that but for the opposition of the traders the Board of Trade's further proposals to make automatic couplings also compulsory might have been carried. The only other serious accident of the year was at Longsight on October 4th, when two light engines, which the signalman thought he had shunted, were run into by a passenger train, causing six passengers to be killed. In this instance, the Board of Trade report drew attention to excessive hours having been worked. That was a matter very much to the fore at that time.

On January 1st the Great Eastern line from Shenfield and Hutton was opened to Wickford and was carried on to Southminster on July 1st. The branch from Wickford to Southend and that from Woodham Ferris to Maldon were brought into use on October 1st. The Caledonian extended its Greenock branch to Gourock on June 1st, and as that point was further from Glasgow than Prince's Pier, Greenock, the company secured a greater part of the Clyde steamboat traffic, of which the Glasgow and South-Western had had the greater share. But the most important opening was that of the Ardwick Curve on July 1st, as it allowed the Midland to enter Manchester, Victoria, from the south, and to work its own trains with vehicles from St. Pancras to Bolton and Blackburn. On the same date the Midland also worked its own trains between Hellifield and Manchester and Liverpool.

Among the local Acts obtained in 1889 were those for the acquisition of the Cornwall and the Llanelly by the Great Western, the Ballymena and Larne by the Belfast and Northern Counties, and for the amalgamation of the Wirral and the Seacombe, Hoylake and Deeside as the Wirral.

The question of railway charges was again very much in evidence during the year. The companies, in order to be on the safe side, put the maxima in the new charges they had to lodge by February, 1889, unreasonably high. These charges were referred to Lord Balfour of Burleigh, the Parliamentary Secretary to the Board of Trade, and Mr.—later Sir—Courtenay Boyle, Assistant Secretary, Railway Department, who inquired into them in public. The sittings occupied no less than 85 days, and the evidence filled more than 3700 pages. The report was issued on August 18th, 1890, and contained a suggested classification and schedules of maximum rates.

Mention was made, in Article No. XXIII., when dealing with the events of 1879, of the introduction of Tyer's electrical tablet system for controlling single lines. That invention was followed by the electrical train staff of Messrs. F. W. Webb and A. M. Thompson of the London and North-Western, which was first tried on the Bedford and Sandy branch of that system in 1889.

1890.—The leading engineering event of the year 1890 was the formal opening on March 5th of the Forth Bridge, 1½ mile long, the main feature of which is the two great central spans of 1710ft. each. This great work was the subject of a Supplement to THE ENGINEER of February 28th. The new railways that joined up the bridge were brought into use on June 2nd. Other openings were:—Chester-Dee Bridge, on March 31st; Edington–Bridgewater, July 17th; Halifax, High Level, Railway, September 5th. In view of its recent re-opening after reconstruction, it will be interesting to recall that the City and South London was brought into use, as between King William-street and Stockwell, on December 18th, 1890. It was the first electric railway in London. The London and South-Western ran over its own metals from Lydford to Plymouth from June 1st.

There were two accidents during 1890 which may be regarded as classic. The first, at Carlisle, on March 4th, was due to mishandling of the vacuum brake by the driver of the 8 p.m. from Euston, who, further, when he found his vacuum exhausted, changed it from automatic to simple vacuum, and so took the brakes off and lost control of the train. A collision with a light engine in Carlisle Station resulted, and four passengers were killed. It was said at the time, and the impression still prevails, that the vacuum brake was frozen, but contributions by Messrs. R. M. Deeley and L. Archbutt to THE ENGINEER of June 27th and July 11th, 1890, proved that it could not have been. The other accident was at Norton Fitzwarren on November 11th, when ten passengers lost their lives. A goods train had been shunted from the down to the up line, and the signalman, forgetful of this fact, lowered his signals for a special up passenger train. The accident was classic in that it led to innumerable inventions for protecting trains "shunted across."

The Great Eastern obtained powers to acquire the Hunstanton and West Norfolk, and the Midland Great Western powers to absorb the Great Northern and Western of Ireland.

1891.—On May 1st, 1891, there was opened the City of Dublin Railway, which gave access between Westland-row Station, Dublin, of the Dublin, Wicklow and Wexford and the Great Northern of Ireland at

Amiens-street. No other work of importance was brought into use during the year, and there was only one serious accident. It happened at Facit on August 29th, when a stone train descending the heavy gradients from Bacup got out of control, ran forward, and caught up a passenger train. Three passengers lost their lives in consequence. The total—five—of passengers killed in railway accidents during 1891 showed the best record for any year up to that time.

The failure, on May 1st, of a cast iron girder under a passenger train at Norwood Junction, led to all the companies overhauling those of their underbridges which had cast iron girders. There were eighty such bridges on the London, Brighton and South Coast Railway, and their renewal cost that company £35,000. Moreover, the company had to pay £20,000 in compensation for personal injuries.

The various railway companies submitted their proposals as to charges, based on the recommendations of Lord Balfour of Burleigh and Mr. Courtenay Boyle, and each schedule became that particular company's Rates and Charges Confirmation Act. Nine of these were sanctioned in 1891 and the remainder in 1892.

The opening weeks of the year were darkened by the Scottish railway strike, which arose out of the long hours and the comparatively poor conditions of the railwaymen in Scotland. The English railways had already awakened to their responsibilities, and had reduced the hours and increased the pay of their men. At the half-yearly meeting of the Great Western in February, 1891, for instance, it was stated that that company was paying £100,000 a year more than before. So strong was the public feeling on the matter that a Select Committee, under the presidency of Sir Michael Hicks-Beach, was appointed on February 3rd.

1892.—The principal openings of the year 1892 were:—From Fairfield to Fallowfield, on May 2nd; Beighton–Staveley, on June 1st, and Staveley–Chesterfield, on June 4th; Aviemore–Carr Bridge, July 8th; Launceston–Tresmere, July 28th; Chalfont-road–Aylesbury, September 1st. During the second half of the preceding year the widening between Clapham Junction and Waterloo was completed. This work necessitated the erection of a new signal box at the entrance to the latter station. The signalling there—both mechanical and electrical—was of a most complete character. It was brought into use gradually, in particular on May 1st and 15th. Of greater general interest was the abolition between May 20th and 23rd of the last of the broad gauge.

Two of the accidents of the year drew attention to the growing use of what was called the "warning arrangement," whereby the principles of the block system were broken, provided the driver was warned that the line at the next signal-box was obstructed. One of these mishaps occurred at Derby Junction, Birmingham, on May 27th, when a passenger and a servant were killed. The other happened at Esholt Junction, where five passengers lost their lives. Irregular block working at Bishopsgate on June 14th caused a collision, which killed four passengers, and ten were killed on November 2nd in a collision at Thirsk, when an up Scotch train was accepted although a goods train occupied the line.

The principal local legislation of the year was the granting of powers to the London and South-Western to acquire, as from November 1st, the docks at Southampton.

1893.—Railway charges were again much in evidence during 1893, considerable dissatisfaction was being shown by traders with the revised rates made under the Acts of 1891–92, and another Select Committee was appointed in May. In the same session, as a result of the report, presented in June, 1892, of the Hours of Duty Committee, the Railway Regulation Act—56 & 57 Vic., c. 29—which gave the Board of Trade powers to call for schedules as to hours of duty of railway servants, was passed. The only local Act of note was that setting up the Midland and Great Northern Joint Committee, on the two companies taking over the Eastern and Midlands Railway.

The new lines and extensions of existing lines brought into use during the year included the Staveley Town–Annesley, on January 2nd, which took the Manchester, Sheffield and Lincolnshire into Nottingham; the Liverpool Overhead from Alexandra to Herculaneum, April 7th; Tresmere–Camelford, August 14th, and Camelford–Delabole, October 18th; Donegal–Killibegs, August 18th; Killorglin–Valentia, September 12th; Dore–Chinley, November 6th; Low Moor–Pudsey, December 1st.

Again, there were only two serious accidents. The driver of an excursion train from Blackpool on the night of July 1st evidently reached the very sharp curve then existing at Poulton sooner than he expected, and his train was derailed, causing the death of two passengers. On the 12th of the following month the spring of an engine tender broke at Llantrissant, and in the derailment which followed thirteen passengers were killed.

1894.—The question of railway charges was laid to rest in 1894 by the Railway and Canal Traffic Act, 57 & 58 Vic., c. 54. The main feature of this Act was that even although an increase in a rate kept it within the maximum, the increase could be challenged and would have to be justified. It is significant to note that not until the changes brought about by the Railways Act—a period of nearly thirty years—was any further legislation necessary in respect of the controlling of railway charges.

The main opening of the year was that, on August 7th, of the West Highland Railway from Craigendoran to Fort William, a distance of 99¼ miles. Most of the big mileage about this time was in Ireland, where many railways were built, with State aid, under the Balfour administration. Two such lines, as mentioned above, were opened in 1893, whilst during 1894 two others were partly completed. They were:—(1) The Tuam–Collooney, opened to Claremorris, on April 30th; and (2) the Westport–Achill, brought into use as far as Newport on February 1st, and Mallaranny on August 1st. In England, the Saxby–Bourne was opened May 1st, and the Parsley Hay–Buxton on June 1st.

During a severe gale on December 22nd a wagon was blown out of a siding at Chelford, the points being opened, on to the down main line, and was run into by a goods train and thrown foul of the up line. An up express was approaching at the time, and in the resultant derailment fourteen passengers were killed.

1895.—Except that the West Highland was extended on June 1st from Fort William to Banavie, and on the same day the London and South-Western reached Wadebridge, and, at long last, was connected to the isolated Bodmin and Wadebridge, all the important new lines opened in 1895 were in Ireland. The Galway–Clifden reached Oughterrard on January 1st, and was completed on July 1st; the Westport–Achill was carried on from Mallaranny and completed on May 13th; the Stranorlar–Glenties was opened on June 3rd; and the Tuam–Collooney reached the latter place from Claremorris on October 1st.

The railway accident figures for 1895, like those for 1891, indicated that British railway travel was becoming remarkably safe. Only five passengers were killed that year, two of whom were in the noteworthy derailment of November 10th, caused by a broken rail at St. Neots. This led to the appointment in May, 1896, of a departmental committee to inquire into the question of the loss of strength in steel rails. Many tests and chemical analyses were made on behalf of the committee whose report—Cd. 174—appeared in March, 1900.

The "race to Aberdeen" occurred in August. On the morning of the 21st the 8 p.m. East Coast train from King's Cross arrived in Aberdeen at 4.40, having covered the 523¼ miles in 520 minutes. The East Coast remained satisfied with that, but the West Coast made a final supreme effort and, the following night, made the journey of 540 miles in 512 minutes. The late Mr. Rous-Marten contributed two articles hereon, one to THE ENGINEER of August 23rd and the other a week later.

1896.—The Light Railways Act—59 & 60, c. 48—was passed in 1896 as a result of the recommendations of a committee appointed in the preceding year. How the hopes of those who looked to light railways to assist agriculture, for instance, have failed to be realised may be judged from the following quotation from a leading article in THE ENGINEER of September 1st, 1922:—"In 1896 the Light Railway Commissioners dealt with 256 applications for 2656 miles and an estimated expenditure of eighteen millions in less than four years; but during the next twenty odd years only 456 applications, proposing the construction of 2495 miles and an expenditure of twenty-four millions, were received. Of the total of 712 applications for the twenty-five years 482 were approved, 124 were rejected, 97 were withdrawn, and 9 were deferred. From the annual report of the Commission for 1918 we learn that up to that time only 900 miles had been constructed, of which 550 were light railways as usually known, and it is significant that 325 of the 550 were made by railway companies. Of the one million pounds at the disposal of the Commission for advances, only £203,000 had then been advanced and £178,000 promised." Further legislation in aid of Irish railways was given by c. 34 of the same session. Powers were given for the absorption of the Cornwall Minerals Railway by the Great Western.

The line from Hawarden Bridge to Bidston was opened on May 18th; the Lanarkshire and Dumbarton from Partick to Dumbarton, October 1st; and the first portion—from Lincoln to Edwinstow—of the Lancashire, Derbyshire and East Coast on December 15th.

Again, the number of passengers killed in railway accidents was only five. The most serious accident, as regards personal damage, happened at Little Bytham on March 7th, when two passengers lost their lives in a derailment caused by a flagman, after relaying, having been prematurely withdrawn. The most serious accident, regardless of the personal injuries, occurred at Preston on July 13th, when one of the night down West Coast expresses attempted to take the curve under Fishergate Bridge at about 50 miles per hour instead of the prescribed 10 miles per hour. Whilst the train was wrecked only one passenger was killed.

1897.—In this year the Lancashire, Derbyshire and East Coast, on March 8th, completed its then programme by reaching Chesterfield. On July 19th the Aviemore direct line was extended from Carr Bridge to Daviot, and on November 1st the Dingwall and Skye was carried on from Strome Ferry to the Kyle of Lochalsh. The only accident demanding mention was that of June 11th at Welshampton, when an excursion train was derailed owing to weak track. Eleven passengers were killed.

The Manchester, Sheffield and Lincolnshire, under powers obtained during the year, altered its name to Great Central.

That little but valuable railway, the Port Talbot, constituted in 1894, opened its first section—from Port Talbot to Pontycymmer—on February 14th, 1898; the Lynton and Barnstaple, a 2ft. gauge railway, was opened on May 16th; the Waterloo and City on August 8th; the London and South-Western reached Bude from Holsworthy on August 12th; and the Aviemore direct line, by the completion of the Daviot–Inverness section, was opened throughout on November 11th.

1898.—The Deal-street widening of the Lancashire and Yorkshire was finished during this year. It gave four, instead of two, approach lines into Victoria Station, Manchester, from the west.

Mention was made above, when dealing with the events of 1892, of the two accidents caused by improper use of the "warning arrangement" at converging junctions. A serious accident of that character occurred at Barassie on February 4th, 1898. A passenger train had to cross the path of a goods train. The driver of the latter was warned but overran his signal, and the two engines met almost head-on. Four passengers were killed. The accident was remarkable for the way in which the wreckage was piled up. There were four other bad accidents that year, and the total killed rose to 25. Irregular block working during fog led to a collision at St. Johns, South-Eastern Railway, when three passengers lost their lives. On June 2nd a driver overran the signals at Leyland and allowed his train to run into another, causing two passengers to be killed. A luggage truck falling on the rails in front of a passenger train at Wellingborough on September 2nd caused five passengers to lose their lives, whilst a derailed wagon of timber at Wrawby on October 17th led to eight being killed.

The work of enlarging Crewe passenger station, carrying the goods lines under the main lines and providing vast marshalling sidings, was put in hand during this year. In one of the new boxes—Gresty-lane—electrical operation of the points and signals was tried. The apparatus was another of the inventions of Messrs. Webb and A. M. Thompson, and the method is known as the Crewe system. It particularly deserves mention as being the first power signalling system to be adopted in this country.

1899.—The noteworthy events of the year 1899 are few in number but big in importance. The South-Eastern and the London, Chatham and Dover, after years of antagonism that now seems petty and is certainly wearisome to the historian, made a working agreement which was sanctioned by Parliament and received the Royal Assent on August 1st. On March 21st the Great Central opened its line from Nottingham to Quainton-road, a distance of 91½ miles, whence, by running over the Metropolitan to Canfield-place, it entered its own terminus at Marylebone. Fourteen passengers were killed in train accidents during the year. In each of three cases one passenger lost his life and in each of three other accidents two were killed. The worst accident involved five lives and that was by a collision in a dense fog at Wivelsfield on December 23rd.

The number of accidents to railway servants led to the appointment, in May, 1899, of a Royal Commission, presided over by Lord James of Hereford. The report, Cd. 41, recommended automatic couplings, either-side brakes, the abolition of "propping" wagons, the fitting of power brakes on all engines, better lighting of yards, covering in of rods and wires, and protection of permanent way men.

The operation of signals and points by power on the Westinghouse electro-pneumatic system was adopted in the box opened at Bishopsgate in January, 1899.

1900.—In the Session of 1900 powers were given to the Great Southern and Western to absorb the Waterford and Central Ireland and the Waterford, Limerick and Western.

Some important lines were opened during the year. Included amongst them were:—The City and South London extension northwards from the Borough to Moorgate on February 25th, and southwards from Stockwell to Clapham on July 1st; Stoats Nest–Earlswood, on April 1st; Sheffield District Railway on May 21st; the Central London on July 30th; the Spen Valley line from Huddersfield to Leeds and the first stage—from Patney and Chirton to Westbury—of the Great Western quicker route to Taunton.

There were two serious accidents during the year. At Charing Cross, Glasgow, on March 28th, irregular block working caused a collision in which seven passengers were killed, whilst the Slough collision, in which five lives were lost, occurred on June 16th. The latter was memorable because, in his report thereupon, Sir Arthur Yorke pointed out how objectionable automatic train control would be.

The sequel to the Lord James Royal Commission of 1899 was the Railway Employment (Prevention of Accidents) Act, 63 & 64, c. 27, which is noteworthy in that by it the Board of Trade was empowered, unless the railway companies convinced the Railway and Canal Commission of the unreasonableness of such action, to order a railway company to use or cease to use any appliance.

British Wire-drawing and Wire-working Machinery.

No. XIX.—MISCELLANEOUS MACHINES.*

So far in this series of articles, there have been described most of the principal British machines employed in the wire industry of this country. There are, however, many factories, specially round about Birmingham, where wire is worked up into a host of useful articles, by means of quite special machinery. Many of these industries have been built up on the ingenuity of some member of the firm in devising appliances to produce the desired result, and only naturally these people do not always care to disclose their methods. The majority of these special machines are, however, very simple and comprise a series of cam-operated tools or fingers working in conjunction with formers, round which the wire is bent. Some of them also are very old—there are still at work in Birmingham the machines which were used to form the wire shanks of the Army buttons used during the Crimea War—but little use would be served in describing these machines, even if the owners were willing that it should be done, as their application is limited, and every engineer will appreciate that by arranging for the movement of the tools in several planes, practically any shape of wire article can be produced.

There are, however, several minor wire-working machines still to be dealt with, and they can be appropriately grouped together. The first of them is illustrative of the bending process just referred to.

Paper Clips.

The machine illustrated in Fig. 148, which is by Mr. E. White, of Redditch, is used primarily for making the familiar clips used for holding sheets of correspondence together, and its action can be followed with the assistance of the diagram, Fig. 150.

The wire is drawn off a swift, through a set of straightening pegs, and through a tunnel cutting-off die, by a cam near the driving pulley, on the left, which is not very clearly visible in the illustration. The wire is cut off to length and immediately two of the slides, seen in the centre of the machine, descend and bend the wire into the form shown in 1, Fig. 150, round a pair of projecting pegs. The second operation is to bend the left-hand end round again, by means of a horizontally moving tool, as shown at 2, Fig. 150. This slide then recedes and another of the vertical tools comes down to make the bend shown by 3. In the interval, the peg on the left, round which the wire was first bent, has, of course, receded. Another movement of the left horizontal slide produces the formation shown at 4, and a stroke of the corresponding horizontal slide on the right completes the coiling of the clip to the shape shown at 5.

In some cases the clip is then considered as being complete, and the pegs, round which it has been formed, recede, so that it may fall clear. The better class of clips, however, have the end of the first loop bent slightly out of plane, to give the slip a free lead on the edge of the paper, and this bend is effected by a transversely moving slide in the front of the machine, which can be plainly seen in Fig. 148, and which completes its stroke just before the bending pegs release the clip.

All these operations are effected by means of cams on the single main shaft running across the machine, and the precise form of the clip is naturally dependent upon the shape of the tools and the sequence of their operation. The rate of production is some ninety clips per minute.

A simple little machine for much the same purpose, but which is worked by hand, is represented by the engraving, Fig. 151. In this case the principal forming tool is carried by the vertical spindle, rotated by a hand lever through toothed gears. The wire is bent by this tool round a former fixed on the base, and a subsidiary slide, worked by a cam on the vertical spindle provides an opportunity for making compound bends. Such objects as skewers, button hooks and so forth are commonly produced on machines of this type which are made to handle wire up to so large as No. 6 gauge.

Hair-pin Machines.

The actual operation of bending hair-pins is really a very simple matter, as it is effected by merely pulling a length of wire by the middle between two stops, so that the two ends are folded together, but the machine used for the purpose is of a fairly complicated nature, as it has to perform several other operations. That shown in Fig. 149, which is capable of producing some eighty pins a minute, is made by Mr. E. White, of Redditch.

The wire is taken from a coil on a swift and drawn through a set of pegs, which can be seen on the right in the illustration, to straighten it. The feed is effected by the lever A, which is driven off the bottom shaft of the machine, and is slotted at the end so that the length of wire fed forward at each stroke can be altered to suit the size of pin required. The straightened wire is projected across the table of the machine and under two pads B B, which are pressed down to grip it by means of the lever C, and a cam on the transverse shaft D at the end of the machine. As soon as the wire is held by the pads, it is cut off by a tool operated by a cam on the back end of the shaft D.

The pads B B are then moved forward by the cam E, which bears against a roller on the slide carrying the fulcrum of the lever C. The consequence is that the wires are rolled on their own axes as they move forward along the table, and as they go they travel across the faces of a pair of mills, one of which is shown at F in Fig. 149—the other is, of course, hidden behind the machine. These mills have file-cut teeth, similar to those used in ordinary pin making, and are driven at a very high speed by belts from the bottom shaft. The bearings of the mills are fitted in adjustable brackets, so that they can be set to suit the length of pin being made. The angle at which the wires are presented to the mills is such that the arris left by the cutting-off tools is removed and a blunt conical point is produced. There is, of course, no necessity to give the wires a fine point.

The wires continue to roll forward and finally drop over the end of the table on to guides. At this moment the plunger G is pulled down by the crank on the end of the bottom shaft. A nib on the plunger engages the wire at the centre and pulls it down between the two guides, so that the wire goes downward with the two ends pointing up and the bend is formed about the rounded face of the nib. A plain hairpin is thus formed, but nowadays they are almost always made with crimps or waves to increase their holding properties. These crimps are produced by a pair of levers, one of which is shown at H, that rock forward appropriately formed tools at J. These tools pinch the wire against the correspondingly formed sides of the bending nib. The crimps would prevent the completed pin from falling clear of the machine, so the bending tool is arranged to be retracted into the plunger G when it has performed its functions, and for this purpose a little trigger is mounted on the upright rod K, while the cam and lever seen just below the letter D withdraw the tool round which the pin is bent. The pins are then free to fall out and are delivered by the shoot below.

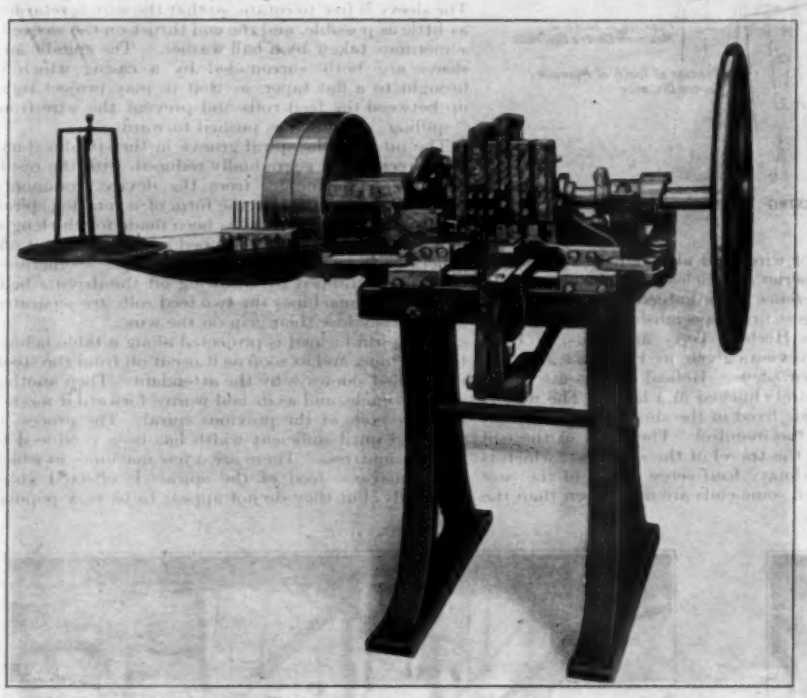


FIG. 148—PAPER CLIP MAKING MACHINE—E. WHITE

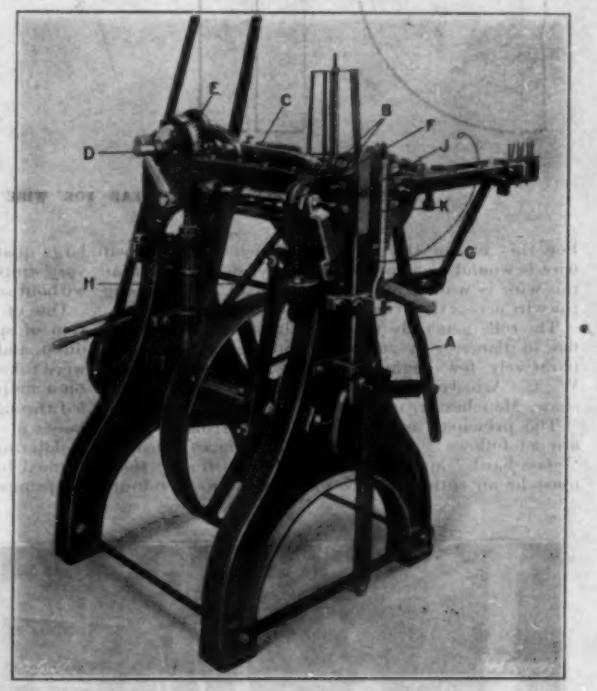


FIG. 149—HAIRPIN MAKING MACHINE—E. WHITE

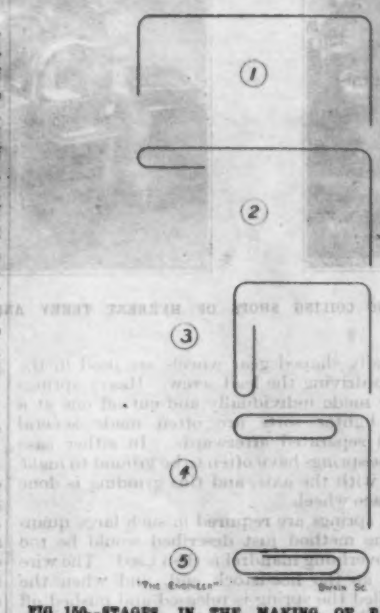


FIG. 150—STAGES IN THE MAKING OF PAPER CLIPS

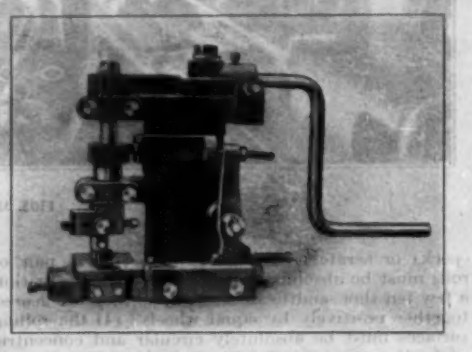


FIG. 151—HAND BOWING MACHINE

Flattening Wire.

The process of flattening round wire by passing it between a pair of rolls would appear to the uniniti-

* No. XVIII. appeared December 5th.

ated to be a very simple matter, but, as a matter of fact, it is a difficult operation requiring special machinery. An illustration of the wire flattening department at Messrs. Ryland's Warrington works appeared on page 259 *ante*.

A plain pair of rolls, geared together and mounted in a very substantial housing, is used, and the wire is led through guides to prevent it moving across the face of the rolls. In the case of steel wire it is lubricated before its passage. It might be thought that wear of the rolls could be equalised by allowing the wire to travel back and forth across them, but if it were allowed to do so the flattened wire would be wavy and out of shape. It must therefore be rigidly confined to one place on the rolls until the coil has been completed, and it is only when the face of the rolls has worn that the working place is altered.

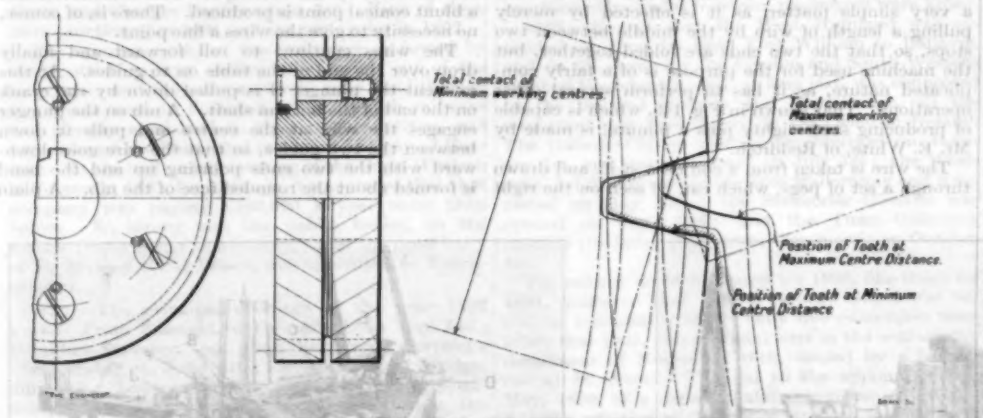

Total contact at Minimum working centres.
Total contact at Maximum working centres.
Position of Tooth at Maximum Centre Distance.
Position of Tooth at Minimum Centre Distance

FIG. 152—DOUBLE HELICAL GEAR FOR WIRE FLATTENING MACHINES

For this reason the drum on which the flattened wire is wound, is arranged to move sideways, so that the wire is wound on evenly—instead of traversing the wire across the drum.

The rolls generally used for this class of work are 6in. in diameter by 2in. wide, and are made by comparatively few engineering firms, among which Sir W. G. Armstrong, Whitworth and Co., of Openshaw, Manchester, must be mentioned.

The principal requirements of a satisfactory roll are as follows:—(1) The rolling surfaces must be "glass-hard" and of a mirror-like finish; (2) there must be an entire absence of even the most minute specks or scratches on the surfaces; (3) a pair of rolls must be absolutely identical in diameter within a few ten thousandths of an inch, as they are geared together positively by equal wheels; (4) the rolling surfaces must be absolutely circular and concentric with the axes of rotation of the spindles; (5) the rolling surfaces must maintain straight line contact.

If condition (1) is not fulfilled, the rolls will have only a short life and soon become scored or grooved. In the case of condition (2) the presence of a minute speck or cavity on the surface means that a corresponding slight projection or point will be raised on the surface of the wire, and this is fatal. If conditions (3) and (4) are not fulfilled, the rolls will produce wire of varying thickness. Deviation from condition (5) results in wire of irregular section.

In many factories the pairs of rolls are geared together with ordinary straight tooth spur wheels, and if these gears are not machine cut and made very accurately an irregular action is imparted to the rolls, which is reflected in an irregularity in the thickness of the wire produced. Messrs. Armstrong have, however, recently designed a pair of double-helical gears—as shown in Fig. X 4—which overcomes this difficulty. One of the wheels is of steel and the other bronze, and the centres can be displaced considerably in the process of adjusting the rolls for the thickness of the wire, while maintaining continuous tooth contact, so that a very smooth movement is given to the rolls, and the thickness of the wire is kept constant.

SPRING MAKING.

The manufacture of coiled springs consumes very large quantities of wire, and although the process is very simple, this series of articles would be incomplete without some reference to the subject.

One of the largest firms specialising in the production of springs is Herbert Terry and Sons, of Redditch, and the two views given in Figs. 153 and 154 were taken in their shops. Helical springs are coiled on a simple mandrel chucked in a lathe. The wire is led through a guide fixed in the slide rest and slipped under a stop on the mandrel. The pitch of the coil is determined by the travel of the slide rest, which is worked by an ordinary lead screw; but in the case of springs in which some coils are more open than the others, specially shaped gear wheels are used in the train of gears driving the lead screw. Heavy springs are generally made individually and cut off one at a time; but lighter sorts are often made several together and separated afterwards. In either case the ends of the springs have often to be ground to make them square with the axis, and this grinding is done by hand on face wheels.

Some light springs are required in such large quantities that the method just described would be too slow and an overhung mandrel is then used. The wire is coiled on at the headstock end, and when the mandrel is filled the spring is released and pushed off into a pipe. The winding is continued and a spring is thus produced which may be 150ft. or so long. The pipe which accommodates the completed part of the spring is generally led below the floor and may make a complete circuit of the shop below the boards. The spring is, of course, subsequently cut up into the required lengths.

The peculiarly shaped springs, with a waist in the centre and wide flared ends, used by upholsterers, are made by a rolling process. The wire is passed between three grooved rolls, set at a slight angle to give the pitch to the spring. The centre roll is mounted in a slide and is moved up and down this slide by a cam so that the curvature given to the wire is less at the beginning and end than it is at the centre of the spring. In some shops the end of the wire is "knotted" round the previous turn by a machine, but more generally this operation is done by hand in a simple press, which first bends up the end at right angles and then folds it over the wire.

WIRE MATTRESSES.

The production of the common wire spring mattress involves the consumption of a large amount of high-class steel wire every year, and is carried out by quite a large number of firms; but it is a peculiar thing that it is very difficult to get any precise details as to the construction of the machines involved. This reticence is all the more remarkable in view of the fact that the mechanism involved is extremely simple in principle. The arrangement can, however, be described in a very few words.

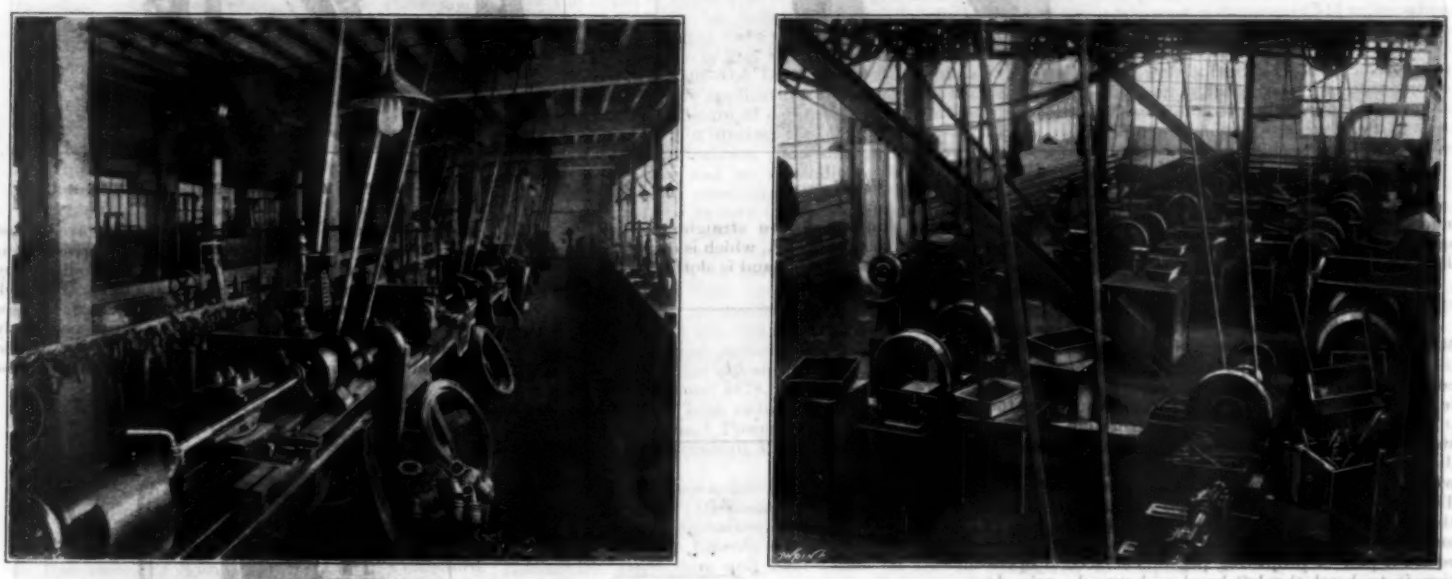
The wire, which must incidentally have been drawn to the exact temper necessary, is pushed by a pair of feed rolls into a spirally (helically) shaped tunnel. This tunnel is formed by cutting a groove round a spindle and surrounding it by a closely fitting sleeve. The sleeve is free to rotate, so that the wire is retarded as little as possible, and the end thrust on the sleeve is sometimes taken by a ball washer. The spindle and sleeve are both surrounded by a casing which is brought to a flat taper so that it may project right up between the feed rolls and prevent the wire from "spilling" out as it is pushed forward.

The pitch of the spiral groove in the spindle starts very steeply and is gradually reduced, with the result that the wire emerges from the device, commonly known as a "giraffe," in the form of a rotating spiral.

When sufficient spiral has been made for the length of a mattress the feed is stopped and the wire cut off, generally by a treadle operated shear. Sometimes the feed is stopped by throwing off the driving belt, but in other machines the two feed rolls are separated so that they lose their grip on the wire.

The spiral formed is projected along a table behind the machine, and as soon as it is cut off from the stock it is pulled sideways by the attendant. Then another spiral is made, and as its end worms forward it meshes into the coils of the previous spiral. The process is repeated until sufficient width has been produced to make a mattress. There are a few machines in which the transverse feed of the spirals is effected automatically, but they do not appear to be very popular on account of the great variety of sizes of mattress required by the trade and the consequent necessity for adjusting the mechanism.

It is common for each spiral to be formed by more than one wire and then the grooves in the spindle and feed rolls have, naturally, to be correspondingly enlarged. Up to within quite recent times it has been the practice to provide the extra accommodation for additional wires by widening the grooves in the feed rolls; but the arrangement had the objection that even the slightest variation in the gauge of the wires resulted in one or the other not being gripped properly and fed forward. Mr. Herman Kershaw, of Liversedge, Yorks., has, however, overcome the difficulty by the simple expedient of piling the wires, one on the top of the other, in deep grooves. Then not only does the law of averages help matters, but the wires grip one another and consequently all are positively



FIGS. 153 AND 154—SPRING COILING SHOPS OF HERBERT TERRY AND SONS

fed forward. Incidentally it is noteworthy that the manufacture of these feed rolls is a highly skilled art, as their conditions of service are very severe.

By developing the principle of the "giraffe" in the way of varying the cross-sectional shape of the spindle and giving it a positive rotary drive, the form of the spiral may be adapted to a variety of purposes, such, for instance, as the production of the flat meshed fencing which looks rather like a wire door mat, but the majority of the machines used in that industry are of German origin and consequently do not come under our present purview.

Internal Combustion Marine Engine Trials.

INSTITUTION OF MECHANICAL ENGINEERS (NORTH-WESTERN BRANCH).

AT a meeting of the North-Western Branch of the Institution of Mechanical Engineers, held on Thursday, December 4th, the First Report of the Marine Oil Engine Trials Committee, which was read in London on November 21st, was presented by Mr. S. B. Freeman. A written communication by Mr. Chas. Day was read by the hon. secretary. Mr. Day said he noted from the particulars given that the fuel oil used was of very excellent quality and had a good calorific value; it was therefore in every respect an oil with which good fuel consumptions might be obtained. But it was to be regretted that the series of tests for any given torque was made over such a limited range, as shown in Fig. 20 of the paper. For instance, the test at full speed was limited to full torque. With land engines which ran at a constant speed it was, of course, necessary to take tests from zero up to full torque at full speed. Had that been done in the present case comparisons with land engines could have been very fully made. The indicator diagrams showed that the fuel settings had been intentionally made to give a rise of pressure during combustion, and in Test A. 15 that rise was given as from 461 lb. to 606 lb. per square inch. A rise of pressure such as that was very beneficial from the point of view of fuel economy, but it meant that all parts of the engine must be made much heavier than if the rise of pressure were avoided. The outlet temperature of the cooling water at full load was about 128 deg. Fah. That high temperature was favourable from the point of view of fuel consumption, but with certain waters was liable to cause deposits in water jackets. The interest of the thermal balance sheet would be increased if the figures were expressed as percentages. The percentages for Test A. 15 worked out approximately as follows:—

	Per cent.	
Brake horse-power	31	
Compressor	2	
Friction	5	
Jackets	11	38
Manifold	10	
Heads	12	
Pistons	3	
Air compressor jackets	2	
Exhaust	24	

Mr. Byrne said it would be noticed that a very high maximum pressure was obtained on Test 15, namely, 606 lb. per square inch. Before that the maximum pressure had been about 590 lb., and it had been found that the fuel consumption then was very high—about .45 lb. per brake horse-power. Permission had been obtained from the Institution of Mechanical Engineers to raise the pressure, and the result was that the fuel consumption immediately fell to .425 lb. Actually the Sycamore was now running at about 550 lb. maximum pressure. It would be noticed that the machinery weight and the general specification of the Sycamore were very substantial. His firm had made certain that the reliability of those first two vessels should be absolutely unassailable. With regard to the bad fuel consumption, the makers had tried to lower it. They had tried all sorts of things: changed piston rings, slackened bearings, and altered the fuel valves, but they could not with low maximum pressures reduce the fuel consumption below that shown—.425. They had now tried four engines of that type and were convinced that that was the fuel consumption of the engine. Incidentally, there were other builders on the North-East Coast who had thought that they got .431, but actually found that they got less when they analysed very carefully. The makers had started these engines with a lapped form of piston ring, and thought they could improve matters by having diagonal joints, but they had obtained no better results. They had, however, obtained no worse results. They found out that they had to have an ample axial clearance of the ring. They had also found that it did not really matter what joint they had; they could not get a scrap of difference in the fuel consumption. They gave the ring about 4000ths inch clearance. The Sycamore had completed two round trips—a distance of about 2500 miles—and the fuel consumption was 11¼ tons. The fuel consumption of the main engines was exactly as it was in the shops, and that was with a fully loaded ship.

Professor Stoney made comparisons of the results obtained from the Sycamore with tests of a liner of 16,400 tons, 17 knots, and 12,500 horse-power with double-geared turbines. The steam pressure was 220 lb. and the superheat was 100 deg. Fah.—about normal. She took 10.05 lb. of steam per shaft horse-power and .876 lb. of oil. The oil had a calorific value of 19,000 B.Th.U. The overall efficiency of the turbines was only 67 per cent. and of the boilers only 67 per cent. What were the reasons of that? First, they had only a vacuum of 28.3in. with a sea temperature of 57 deg. On land, with that water temperature, they should get 28.9in., and Professor Stoney thought that if they had not the very wasteful steam-driven auxiliaries which were generally found on board, and had electrically driven auxiliaries, they should get 73 per cent. instead of 67 per cent. There was also no reason why the superheat should not be raised to 200 deg. That would reduce the consumption of oil in the boilers to .73 lb. At sea, by proper arrangements, they should get boilers of 80 per cent. efficiency. That would reduce the oil per shaft horse-power to .61 lb. Another thing was intermediate feed heating; that should, in fact, take off another 5 per cent., which would make the oil per shaft horse-power .58 lb., compared with .55 lb. on the Sycamore. That was to say, that a steam installation properly put in would have only 5 per cent. more oil consumption than the Sycamore. The weights on board the Sycamore were very large. The total amounted to under 3 horse-power per ton. A very much better figure could be secured with suitably constructed marine engines and boilers, and Professor Stoney was of opinion that if the extra weights necessary were employed to get real economy, results could be attained by a steam installation very close to those obtained on the Sycamore.

Mr. Orton, referring to the high maximum pressure, said that it had always been taken in Diesel engine practice that no increase of pressure occurred during combustion, and that condition had always been thought ideal. During the last few years, however, there seemed to have been a tendency to try to get increased maximum pressure from the beginning of combustion, and there was no doubt at all that doing that did bring down the fuel consumption. In that particular case to which Mr. Byrne had referred, he (Mr. Orton) thought that it would have been better to have the compression pressure higher. He noticed it was rather lower than that usually adopted on normal Diesel engines. If they were going to have higher pressures at all, why not put them on to compression? In that way they could get equally good fuel consumptions. A point of interest about the diagram for fuel consumptions was that the line of fuel consumption per indicated horse-power had a very considerable curl up at the low torque end. That was rather curious. Diesel engines on land with fuel consumption and low loads per indicated horse-power were always better than at high loads owing to very much greater excess of oxygen and better conditions for combustion.

Mr. Wright Baker said there was one measurement he would like to query, and that was the measurement of the exhaust gas temperature. In some experiments on petrol engines fitted with thermo-couples and with exhaust gas column the exhaust gas column always gave exhaust gas temperatures higher than those given by the thermo-couple. At the same time, when the exhaust gas column showed the temperature to be falling, the thermo-couple showed the temperature to be rising. He did not know whether there were any similar comparative results on a larger engine, but it would be interesting to know.

Mr. Bevan said that the mechanical efficiency which one would expect from the running down test would be higher than the normal, because in the cylinder in which the fuel was not injected the compression pressure would still be acting on the top of the piston, and a certain amount of indicator work would be done by that compressed air, thus leading to a higher mechanical efficiency than for the engine running under normal conditions. That fact indicated that the indicated thermal efficiency as given for most of the trials from the normal indicator diagrams was too high, and pointed to the fact that the indicator gear was not of the best. If the figures were taken as given, 93 lb. per square inch for the normal indicator gear and 101 lb. per square inch for the more elaborate gear, and were compared with those for Trial 15, the correction, taking into account the new gear, would bring the figure to about 99 lb. per square inch, and give a mechanical efficiency of 73.5 as against 79.8, 73.5 comparing very well with the 73.2 obtained by the cutting-out test.

Mr. Harrison, speaking of the relative merits of the common supply system and the independent pump system, said that undoubtedly the successful working of the multi-cylinder heavy oil engine depended to no small degree on the ease with which the amount of fuel could be distributed to the various cylinders, so that the power developed in each cylinder bore a correct relation to the total power developed by the engine, but his experience was that the common supply system lent itself much more readily to that distribution than the independent pump system. He had been fortunate enough to take to sea one of the first boats that was ever fitted with the common supply system. That boat's engines were made with a pump of sufficient capacity to supply to the engine about double the amount of fuel that it would ever require, and the surplus fuel was allowed to discharge, whilst the relief valve discharged the pressure. That was a most unfortunate arrangement, and gave anything but satisfaction. The pressure fluctuated so much that most unsatisfactory running resulted. But when that difficulty had been overcome the engines in service proved themselves to be of the best type that was ever put into a submarine, and all boats that were fitted then with independent pumps were to some extent converted. He did not think there was any question as to which system was the better one in practice—it was so much easier to distribute the power equally between the various cylinders.

Australian Engineering Notes.

IN reply to a question in the Victorian Parliament, the Minister for Water Supply said that the estimated cost of making available at the Sugarloaf Weir, on the Goulburn River, a unit of 300,000 acre-feet capacity, would be £1,200,000, but that that sum included much work connected with the second unit. Assuming that by second unit was meant a storage with an additional capacity of 600,000 acre-feet, the additional cost would be about £1,500,000.

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THE Warrnambool (Victoria) City Engineer has prepared a report on the proposal to provide a dock harbour by dredging out Lake Pertobe. Preliminary estimates given recently to the Outer Ports Commission put the cost of the work at between £150,000 and £250,000.

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THE Cairns (Queensland) Harbour Board recently placed before the State Premier a plan for wharf and port improvements at Cairns. The plan embraces the construction of an additional 150ft. of concrete wharf at a cost of about £65,000, and the reclamation and resumption of swamp lands at a cost of about £10,000. The proposal is being considered.

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THE Brisbane (Queensland) Central Telephone Exchange is to be converted into the automatic system. The equipment, to be installed, will cost about £447,670.

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THE New South Wales Public Works Department is inquiring into the proposal to construct two bridges across the Richmond River at a total cost of £73,000. One bridge, it is proposed, will be built at Lismore at a cost of £35,000 and the other at Woodburn at a cost of £38,000.

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MESSRS. GARLICK AND JACKMAN, of Adelaide, have secured a contract to build a new railway station at Adelaide at a proposed cost of £250,000. The station will comprise three floors, and it is stated that when completed it will constitute the most modern railway building in Australia.

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AN ambitious scheme to connect Hobart with the West Coast mineral fields of Tasmania by means of an electric railway was outlined recently by Mr. A. H. Ashbolt, ex-Agent-General for Tasmania. It is proposed that, at the Hobart end, the line should start from Glenora and that the western terminus should be at Rosebery. That would be in the heart of the potential mineral region of the West Coast and in the very spot where the most important part of the development of the future of the great zinc, lead, and sulphide branch of the mining industry of the State would take place. The railway, when constructed, would be 140 miles in length, and the capital required would be not less than £1,000,000.

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THE Launceston (Tasmania) Marine Board is considering the provision of a dry dock at Launceston to take vessels up to 350ft. in length. The engineer has reported favourably on the proposal. The dock, which will probably be of concrete, is estimated to cost from £50,000 to £70,000.

BIG RAILWAY DEVELOPMENT IN SOUTH-EAST AFRICA.

OWING to the lack of a bridge across the Zambesi River, the railway journey from Beira to Blantyre takes about two days—the distance being 350 miles—and passengers spend the night on the ferry boat, which has cabin and saloon accommodation. When the proposed bridge over the river at Sena has been built it should easily be possible, according to the *S.A. Mining and Engineering Journal*, to travel from the port to Blantyre or *vice versâ* in less than 24 hours—a reduction of 50 per cent. on the present timing. A point worth noting about the rolling stock used on this southern section of the trunk route from Beira to Nyasaland is that the "Garratt" type articulated engines are used. An extension of the railway from Blantyre to the south end of Lake Nyasa, about 140 miles, will complete the trunk route from Beira to the southernmost of the great African lakes. Another railway project in connection with the Beira–Nyasaland route is the construction of a branch of 115 miles from near Chiromo to the Benga colliery, near Tete, which will give a through line 385 miles long from the coalfield to Beira. It is hoped to develop a coal traffic of 750,000 tons per annum within a few years of the completion of the bridge and the coal branch. Beira is much nearer to East Africa and Asiatic markets for coal than either Lourenço Marques or Durban, so that, provided the coal is of good quality, there are excellent prospects of developing a large export trade, while bunkering requirements at Beira and the needs of the Beira–Nyasaland railways, which now use wood fuel, will absorb large quantities of Zambesi coal.

THE Welsh Highland Railway, which is a recent amalgamation of new and old lines in the Snowdon district, will cease to carry passenger traffic, at all events for the winter months, to-morrow, the 13th. The new line, opened in June, 1923, has not paid.

A New Centrifugal Pump.

A NEW form of centrifugal pump, which is primarily intended for handling liquids heavily charged with solid matter, such as sewage, has recently been brought out by the Wallwin Company, of Saltisford Ironworks, Warwick.

This pump, of which we give an illustration with the suction cover removed, is of the single inlet type with an overhung impeller. The impeller is quite distinctive and

THE WALLWIN CENTRIFUGAL PUMP

has a single vane of the form shown in the engraving. It is of the same width as the diameter of the suction branch, so that any solid substance which can pass the suction inlet can also go through the impeller. The inlet is, of course, in the centre of the casing, opposite the sweeping curve of the impeller vane.

In order to minimise the liability for grit to get into the stuffing-box and score the shaft, a deep helical groove is cut in the boss of the impeller and by producing a constant flow away from the stuffing-box sucks away the grit. As an added precaution the shaft is protected by a phosphor-bronze sleeve, which is forced up against a shoulder on the shaft when the impeller is screwed on. The thread on the shaft is left-handed, of fairly coarse pitch, and as the impeller rotates clockwise it always tends to tighten itself on the shaft. It is, nevertheless, a comparatively simple matter to remove the impeller for the renewal of the bronze sleeve. The end thrust on the shaft is taken by a ball washer, while the bearings are ring lubricated.

It might be thought that such a pump would be very extravagant of power, but the makers assure us that it will give a higher efficiency than the average clear water pump, while it will deal with solids and semi-solids. In any case the principal object aimed at is to handle liquids carrying large masses of solid matter, and that it apparently does quite effectively. Some tests carried out by the makers showed that a 3in. pump running at 1150 revolutions per minute would deliver 300 gallons a minute against a head of 50ft. on a consumption of 12 horse-power, and would produce a vacuum of 26in. The same pump, delivering 100 gallons against 50ft. head, required 6 horse-power at 970 revolutions per minute, and when pumping 300 gallons against 20ft. head consumed 8 horse-power at 950 revolutions per minute.

These pumps are being made in five standard sizes with inlet branches 2in., 3in., 4in., 5in., and 6in. in diameter.

Electrification of the Natal Railway.

THE electrification of the Maritzburg-Glencoe portion of the Natal main line is now practically completed. Successful tests of an electric train were made early in October on the part of the line between Ladysmith and Estcourt. The train, which comprised trucks and carriages, started from Ladysmith with a steam locomotive and two electric locomotives, the former being employed to draw the train on the down journey, while on the return journey the electric locomotives alone were used.

The portion of line electrified, which is 170 miles in length, passes through some of the most difficult country in South Africa. The power station is situated at Colenso, on the right bank of the Tugela River. The boiler-house contains eight Babcock and Wilcox boilers, each unit consisting of boiler, superheater and air heater, and is capable of producing 60,000 lb. of steam per hour at a pressure of 270 lb. per square inch superheated to 700 deg. Fah. The engine-room equipment consists of five turbo-alternator sets, supplied by C. A. Parsons and Co., Limited, each designed to give continuously an output of 12,000 kilowatts at 6600 volts three-phase, and an output of 20,000 kilowatts for two minutes. The condensers are of the twin type, each consisting of two condenser shells connected together in parallel. There are five circulating water pumps of the vertical centrifugal type driven through flexible couplings and vertical shafts by motors situated in the pump house casement. Five step-up transformers are arranged in an outdoor sub-station alongside the power station. These transformers raise the voltage from 6600 to 88,000 for transmission purposes. There are twelve sub-stations along the electrified route. The motor generator in each of these comprises an alternating-current motor of the synchronous type, direct coupled to two direct-current 1500-volt generators, together with a direct coupled exciter for the motor and a direct coupled exciter for the direct-current generators. The generators are coupled electrically in series and supply direct current to the overhead lines on the track at a pressure of 3000 volts. The total weight of the motor generator set is 60 tons. Two 88,000-volt transmission lines run from the step-up station at Colenso to supply the step-down sub-stations along the route. The length of the transmission lines is about 130 miles each. Each transmission line carries a single circuit, the three wires being arranged horizontally with provision for transposition of the conductors at suitable intervals. Two earth conductors, consisting of galvanised steel wires, are carried on the towers, arranged in a horizontal plane above the plane of the line conductors. The towers are of steel structure spaced from 550ft. to 800ft. apart and are of sufficient height to permit of the conductors being erected with a clearance above ground of 20ft.

The route mileage comprises 168 miles of single track 14 miles of double track, and 48 miles of sidings, the total single track equivalent being 245 miles. The overhead equipment of the track consists of a copper catenary cable supporting a solid grooved copper contact wire by means of droppers. The running rails serve as a return track, the joints being bridged with two copper bonds.

The seventy-eight locomotives, supplied by the Metropolitan-Vickers Electrical Company, Limited, are of the double bogie articulated type driven by four motors carried on the bogies. The one-hour rating of each traction motor is 300 horse-power. The locomotive is capable of exerting 1200 horse-power, which corresponds to a tractive effort of 23,200 lb. at one-hour rating, and a tractive effort of 16,400 lb. continuously. The control system is electro-pneumatic and is arranged so that the locomotives can return current to the overhead line when running on down gradients. A summary of the leading particulars of the locomotives is as follows :—

Weight in working order	About 65 tons
Weight of mechanical portions	About 37½ tons
Weight of electrical portions	About 27½ tons
Type of locomotive	0-4-4-0
Gauge	3ft. 6in.
Motor equipment	Four 300 H.P. motors
Total motor rating	1 hour, 1200 H.P.
Tractive effort—	
One hour	23,200 lb.
Continuous	16,400 lb.
Control equipment	Electro-pneumatic
Traction system	3000-volt D.C.
Current collectors	Pantograph trolley
Brakes, dual fitted ; air pressure for locomotive, vacuum for trains	
Length of body	40ft. 8in.
Overall height of locomotive	13ft.
Overall width of locomotive	9ft. 2½in.
Diameter of driving wheels	4ft.
Wheel base of bogie	9ft. 3in.
Weight per driving axle	16¼ tons
Maximum safe-locomotive speed	45 miles per hour

The Flettner Rotor Ship.

(From a Correspondent at the Trials.)

ON Wednesday, December 3rd, a public demonstration of the Buckau was made in Kiel Bay. The wind was very light and there was no sea. Manœuvres could only be seen through glasses between the heads of several hundred more or less interested spectators on board a crowded steamer. It was more of a "hurrah party" than a scientific demonstration. The steamer lay stationary while the rotor ship described an oblong round her.

With her screw propeller stopped and using the Flettner towers alone the Buckau started with the wind abeam and the towers rotating at some 120 revolutions a minute. The revolutions could be counted by watching a broken black spiral painted on each tower, a very good arrangement for onlookers. She passed some 400 yards away at about 4 knots, which is approximately the speed she would have attained with her original three-masted topsail schooner rig. When half a mile astern she wore ship by stopping the after tower, which came to rest gradually, and, when past the wind, starting it again in the opposite direction, finally reversing the after tower to get both rotating in the same sense. With the wind now on the other beam she sailed closer past the other side of the steamer again and tacked ahead by stopping the foremost tower first this time and passing head to wind. All this manœuvring is analogous to spilling sails and throwing them aback in a sailing ship. She then passed "within a biscuit's throw" of the steamer on her original course, thus completing the oblong. The towers were revolving quite noiselessly, though the "scream" of the motors could be faintly heard.

These sailing manœuvres of wearing and tacking may or may not have been helped by the rudder. No spectators were on board the rotor ship, so I cannot verify this. In reply to subsequent questions, Herr Flettner stated that the ship can wear and stay without a rudder. That may perfectly well be so. She seemed to wear and tack slowly, but then the wind was very light and she might have been as slow in her original rig.

On returning to the quay I went on board with a crowd and saw the one-man control on the bridge. It consists merely of two wheels, like steam valve wheels, on which are arrows working over horizontal scales marked from zero to 120 revolutions in either direction. The wheel marked "Fore Tower" was set at 40 revolutions in one direction and, accordingly, that tower was rotating at 40 revolutions in that direction. I should say a novice would soon learn to manœuvre the ship, once told that all his forces are at right angles to the wind and to revolve the tower so that that side of it which lies towards the direction in which he wants to go, with the wind. A few more instruments, such as wind speed gauge and wind direction indicator and a "speedometer" for the ship would be useful for getting best results.

Arriving at the fore tower and putting my hand close to its surface, I only felt a very small draught. Smoke, from the nearby galley funnel was caught and turned round but not at all violently. The towers are quite smooth with a merely painted surface.

The rotating part of each tower weighs 1 ton and each tower has a "hub" or diaphragm one-third way down inside, revolving on forced lubrication bearings (not ball bearings), one horizontal to take the ton weight and one vertical to take the heavier side propelling thrust. These bearings are set on top of a strong hollow steel mast stepped on the keel. Thus both the weight and propelling thrust come on top of the fixed mast, though there is also a bearing round the lower edge of the tower near deck level, mostly as a steady.

In the fore deck house I saw through a big manhole in the side of the hollow steel mast a reversible motor capable of developing 15 horse-power with a vertical shaft up inside the mast to the "hub" with a small pinion and a 6 to 1 gearing to the "hub." No "brake" is used to slow down the towers. The weight of all this gear is only one-fifth that of the three masts and their sails which it replaced. The centre of gravity of the whole is lower and so gives increased stability.

Herr Flettner, questioned by the British shipbuilders at the hotel, said the Buckau could sail several degrees closer to a head wind than a schooner; but, like a schooner, she must bring a following wind on one quarter. He said a tower could be put outside a Diesel funnel if desired. The projecting caps are very important to confine the wind whirl. He intends to lecture in England during February and to bring the rotor ship to England.

In a pamphlet shown to us and nearly ready for publication it is stated that, since the pressure on the mast is greatest when the tower speed is four times that of the wind, a sudden squall actually reduces the pressure by reducing this relative speed from four times to thrice or twice. Thus shortening sail is automatic and is done by the squall itself. The vessel can lie "hove to" in a gale by slowly rotating the towers in opposite directions, an arrangement which is analogous to leaving a staysail aback in a schooner. Herr Flettner has been waiting a month for a gale in the Baltic. Three towers could be fitted, especially as, there being no stays, the masts can be stepped further forward and further aft than in a sailing ship. They could be made telescopic if required for passing under bridges, but it is not necessary to shorten them when meeting gales, because their resistance is much less than that of ordinary masts and rigging, when not rotating.

My own personal opinion, for what it is worth, is that wherever sails are used these towers would probably be better. In fact, they are good for auxiliary ships. The inventor himself does not claim more for them.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

THE WELDLESS STEEL TUBE COMPANY, Limited, of Wednesfield, ask us to announce that owing to reasons of health Mr. William U. Jackson has been obliged to retire from his position as chairman and managing director of that company, but has decided to remain a director. Arising out of the foregoing, the following new appointments have been made :—To be chairman, Mr. D. C. Lloyd; to be managing director, Mr. R. E. Moynihan.

WE are asked to state that Charles Churchill and Co., Limited, of 9-15, Leonard-street, Finsbury, London, E.C. 2, have ceased to represent the Norton Company, and have entered into an agreement with the Carborundum Company, Limited, of Trafford Park, Manchester, whereby the two organisations will now co-operate in meeting the grinding requirements of British manufacturers with the British-made "Carborundum" and "Aloxite" grinding wheels.

CONTRACTS.

VICKERS AND INTERNATIONAL COMBUSTION ENGINEERING, Limited, of Africa House, Kingsway, London, W.C., has recently received the following orders :—From the St. Pancras electricity supply department for two Vickers-Spearing boilers, with Lopulco equipment; from Synthetic Ammonia and Nitrates, Limited, for two water-tube boilers, fired with pulverised fuel, including coal-handling plant and other accessories; and for a new cement manufactory at Holborough in Kent, for two rotary kilns, 9ft. and 10ft. in diameter by 200ft. long, with coal-pulverising plant and all equipment for dealing with the raw materials and finished product.

RAPID STEAM PLANT ERECTION AT BATH.—A notable achievement in rapid boiler construction and installation has just been completed by Babcock and Wilcox, Limited, for the Bath Corporation. At the beginning of last October the Electricity Department found itself in difficulties owing to delays in connection with its building work, and consequently new steam plant which it had arranged for could not be installed. It was seen that unless auxiliary steam power could be provided the works would have the greatest difficulty in coping with their rapidly increasing winter load. Under these circumstances the engineer, Mr. Francis Teague, sought the assistance of Messrs. Babcock and Wilcox, who prepared a scheme showing the possible installation of a 25,000 lb. boiler in a corner of the existing boiler-house. It was suggested that the plant should be arranged for burning oil fuel, and a complete equipment of burners, tanks, pipe connections and other details was included in the scheme. Special meetings of the Electricity Committee and Corporation were held, at which the proposals were approved, and the necessary sanction for the work to be proceeded with was also obtained from the Electricity Commissioners. The order was placed on October 20th and the contractors completed the installation by midnight on December 4th. The following day the new unit took over the town load and is now in regular service.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Improved Prospects.

THOUGH somewhat quieter conditions prevail in the iron and steel industries of the Midlands, there are indications of a decided improvement in the New Year. December is nominally a poor buying month, consumers having in view the closing of the year's accounts, and the taking of stock; consequently, apart from price considerations, users are buying little more than for current need, so as not to add to stock. There are, however, numbers of buyers who are taking no risks, and are covering their requirements well into the New Year. Particularly is that so with regard to raw iron, many furnaces having three months' orders on their books. The placing of some of the biggest orders ever received by rolling stock makers from home railways is welcome news, for these large requirements will give considerable help to the Staffordshire iron and steel industry in many of its ramifications. Among manufacturers who will be direct participants are the makers of sections, mild steel bars, special welding steel, nuts and bolts, wheels and axles, springs, &c. A certain amount of high-grade bar iron will be required, but the proportion is small in comparison with steel. Buying of materials has already begun, and although there is as yet but little disposition shown, either on the part of buyer or seller, to make long-date contracts, there are prospects of a substantial call for iron and steel in the New Year in the Midlands.

Big Rolling Stock Orders.

Midland rolling stock firms have secured a very welcome and substantial share of the big contracts, aggregating something like 5000 wagons, just given out by the home railways. The larger proportion is required for augmenting the resources of the London, Midland and Scottish R ilway, the balance being a further instalment of the London and North-Eastern's programme. Complete particulars are not, at the time of writing, available, but information gathered from various sources as to the allotment of wagons, &c., to the principal Midland firms is:—Metropolitan Company, Birmingham, 1250; Midland Wagon Company, Birmingham, 750; Birmingham Wagon Company, 340; Derbyshire Wagon Company, 100. The orders include merchandise, mineral and covered goods wagons, cattle trucks, and brake vans. All-steel construction is not specified in any case. Bodies of wood, with steel underframes, are the common type, with necessary adaptations to the class of traffic they are required to carry. The Birmingham Railway Carriage and Wagon Company at Smethwick gets 190 brake vans for the London and North-Eastern and 150 wagons for the London, Midland and Scottish; the Midland Railway Carriage and Wagon Company's allocation from the former group is 250 covered goods wagons and for the London, Midland and Scottish 500 of unspecified class. Of the Metropolitan Carriage Wagon and Finance Company's big contracts, 500 mineral wagons and 250 merchandise wagons are for the London, Midland and Scottish and 500 wagons for the London and North-Eastern. Most of the other rolling stock detailed above is for the London, Midland and Scottish system.

Steel.

Steel business continues to prove moderately satisfactory, and a fair volume of business in the New Year is looked for from Midland rolling stock firms, which now have some excellent orders on hand. Greater steadiness characterises the trade as a whole, and prices have changed very little since last week. Birmingham merchants report that the outlook is distinctly better than it recently was. Internal competition continues very keen, however, and prices are cut very fine in order to secure any contracts worth having. Figures much below the nominal market rates are mentioned in connection with some classes of structural material. Steel bars are readily obtainable at £9 5s., and ordinary tube strip at £9 10s. Some orders have been taken at the easier prices ruling for continental steel. There is no freedom of buying in any direction, though structural material is in better inquiry. Production of joists, sections, &c., at the mills continues over a wide range, enabling constructional engineers to obtain prompt supplies. The weak place in the steel business is the poor demand for shipbuilding material. Steel billets continue to find only a moderate sale at £7 10s., but some producers are keeping up their quotations to £7 12s. 6d., and even £7 15s.

Staffordshire Bar Iron.

Users of Staffordshire finished iron have shown an encouraging interest in their future requirements, in many instances placing orders well into the New Year, especially for best quality bars. This is some encouragement, for the finished iron trade has been, and is, far from brisk. The marked bar mills are working fairly regularly, and no difficulty is experienced in maintaining the basis rate of £15. Other grades of manufactured iron are, however, less easy to sell, notwithstanding that imported material is dearer. The demand is, as yet, very uncertain, and many of the large users of nut and bolt iron are reported to have still on hand fairly liberal stocks, which months ago were obtained at very low prices from the Antwerp shippers. Unmarked bars of Crown quality command £12 15s., and nut and bolt iron is offered at £11 15s. The wagon works are buying rather more medium grade iron as well as iron plates. Iron strip is in fair demand at £13 5s. The Staffordshire tube makers are moderately well occupied, though steel strip being so much cheaper than iron strip receives chief attention.

Sheet Values.

Galvanised sheets have not maintained the recent appreciation. While many of the mills still quote £17 10s. for corrugated sheets of 24 gauge, this is becoming a nominal figure. Business has been withheld by prospective buyers, who were not disposed to go beyond £17 5s. A few orders have been put through at £17 7s. 6d.

The Manufacture of Malleable Iron.

There was a large attendance of Midland ironfounders at a meeting of the Institute of British Foundrymen in Birmingham on Saturday last, when Dr. D. Wilkinson read a paper on "The Manufacture of Malleable Iron." The lecturer stated that the successful manufacture of malleable iron castings involved two distinct processes. First, the production of a casting which was hard, brittle and white in fracture; secondly, the modification by heat treatment of this hard and brittle casting until it became soft, tough and ductile. If the final product was to be of a good grade, the requirements of the second process called for definite limitations in the first. Details of cupola working, annealing, and grading of pig iron were given.

Pig Iron.

The Midland pig iron situation remains fairly satisfactory from the trade point of view, and smelters, no longer under compulsion to liquidate, have settled down to await developments. Though demand is not quite so brisk as it was a week or two ago, prices are upheld on the strength of sales already made. Some of the furnaces have sold a large part of their output over the next three months, and are not prepared to commit themselves further forward. They are under no great anxiety as to the disposal of the unsold balance, the expectation being that consumptive requirements will broaden. Already preparations are in hand for restarting several idle furnaces. Whether they will be actually commissioned depends upon fulfilment of the sanguine forecasts with regard to 1925. Present market conditions do not throw much light on the future, but there is a general impression that another buying movement may be expected at the beginning of the year. Midland foundries have been taking rather more raw iron of late, but that is probably partly due to users having come to the conclusion that they are not likely to get a more favourable opportunity of strengthening depleted stocks. Forge iron is still a very minor feature. The prices current on 'Change in Birmingham to-day—Thursday—were:—North Staffordshire No. 3 foundry, £4 7s. 6d.; Northamptonshire, £3 17s.; Derbyshire, £4 2s. 6d. Forge sorts were quoted respectively £3 17s. 6d., £3 12s., and £3 17s. 6d. Steadier conditions are maintained in the coke market, but smelters are urging the necessity for reduced fuel prices.

Blast-furnace Coke.

Midland blast-furnacemen are still without any assurance as to the price they will have to pay for their coke after this month. A conference with the ovenmen has proved abortive, and no arrangements have been made as to the renewal of negotiations. There is no question of the price being raised. Current market conditions give no warrant for an upward movement. The point on which negotiations have broken down is whether there should be a reduction. Producers of pig iron hold strongly that a further concession is due to them.

North Sea to Midlands.

The completion of the scheme, upon which the Nottingham Corporation and the Trent Navigation Company have spent £500,000, and which will provide through water-borne traffic from the North Sea to the Midlands, is now within sight. One of the last important contracts has just been placed. It relates to the reconstruction of the Nether Lock at Newark, and has been entrusted to a Doncaster firm.

Cannock Chase Miners' Wages.

Cannock Chase miners' wages have been slightly increased for December, the advance ranging from 1d. to 2d. per shift (minimum wage for stallmen), compared with the rates for November. Last December the stallmen were receiving only 9s. 8d. per shift, while in July the figure was 11s. 10d. Under the present rates, pikemen receive 10s. per shift, rippers 9s. 7d., landers 8s. 9d., datallers 8s. 6d., dirt emptiers 8s.; while youths are being paid from 7s. 7d. down to 3s. 2d. (fourteen years of age). Surface workers' wages range from 8s. 11d. to 8s. 9d., with youths' in proportion. These increases in wages are governed by the output, costs of production and prices for the months of August, September and October.

Notts. and Derby Miners' Wages.

The Council of the Derbyshire Miners' Association has, I learn, this week decided to ballot the 20,000 miners in the soft coal seams as to enforcing the restoration of the 7½ per cent. taken off wages by the owners in 1922. The coalowners have so far resisted the demand. Should the ballot be favourable, the usual notices will be served to terminate work. Nottinghamshire is also involved.

Unemployment.

There is a further decline in the number of persons unemployed in the Midlands. The latest statistics show 139,539 persons out of work for the week ended December 1st, as compared with 140,332 the previous week. The figures are made up as follows:—Men, 99,015; boys, 1638; women, 36,249; and girls, 2637. The returns for some of the principal towns are as follows:—Birmingham area, 31,202; Bilston, 2935; Coventry, 2073; Cradley Heath, 4570; Derby, 2113; Dudley, 4334; Hanley, 3548; Leamington and Warwick, 616; Leicester, 3982; Longton, 2919; Northampton, 1953; Nottingham, 8934; Oldbury, 1651; Peterborough, 524; Smethwick, 4651; Stourbridge and Brierley Hill, 4241; Tipton, 2290; Walsall, 5063; West Bromwich, 3339; Wolverhampton, 5387; Worcester, 1874; and Redditch, 1302.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

General Outlook.

THE markets here are all quiet and fairly steady; but so far as new business is concerned, the influences of the near approach to the end of the year and to the stocktaking period are being felt, and but little inclination is shown by buyers to do anything serious. There seems to be a very general opinion here, not only in the iron and steel section, but also in the non-ferrous section, that much more active business may be expected before the end of January, and probably soon after the Birmingham quarterly meeting. Certainly people are prepared to see considerable general improvement next year, and it is possible that the large schemes for fresh expenditure on the railways will give the necessary fillip to the iron and steel markets, so far as the home trade is concerned. As to the foreign trade there are serious difficulties in the way of any very great extension, the principal of these being the high overhead costs of British manufacture.

Metals.

The failure of copper to continue the advance which seemed probable at the end of November has, of course, been a disappointment in this market; but one ought not to expect any steady and continuous rise in copper yet. The general situation is gradually getting better, and it seems probable that we have seen the lowest prices of the time of depression. So far as the price here is concerned, the appreciation of British currency in relation to the American dollar of course tends to disguise any advance. The better rate of exchange must be taken into account. There have been reports of an improvement in the American domestic demand, and that is of importance in the present situation. In Manchester there is a little more confidence, and the consumer is rather more inclined to buy, but of course a good many people will now postpone buying until after the New Year holidays. Large consumers, however, will do well to watch the market, for it is quite possible that a rise may occur in anticipation of the buying for the New Year. Manufacturers have advanced the price of sheet copper to £95 per ton. There is still a belief in America that the European demand for copper will expand to a large extent during the coming year. It may be based on the better buying power of Germany, and the general, although very slow, improvement in commercial conditions throughout Europe. In the market for tin here there has not been any very serious movement. Of late the fluctuations have been confined to a few pounds per ton, either up or down; but English tin has not been sold here at under £200 per ton for some time. There is only a small demand here for consumptive purposes; and the extreme slackness of the tin-plate trade at the moment suggests that we may have to wait a little for the next advance in prices. The market for lead has been a little uncertain. A good many people think that it is dangerously high, but perhaps not sufficient account is taken of the extraordinary increase in consumption. Spelter is a quiet market and rather easy.

Pig Iron.

The market here for foundry iron is considered to be in quite a satisfactory condition, although there is not very much new business passing at present. This, of course, is not now expected; and the small transactions which take place satisfy sellers, for there is a fairly large delivery of iron going on under the contracts made in the first fortnight of November. One notices a very confident feeling amongst makers and selling agents of Derbyshire foundry iron, and with some of them there is a tendency to ask a premium of 1s. per ton upon sales for delivery after January, although others will sell moderately, at the current price, up to the end of March. The lookout for coke prices after the close of this year is uncertain; but so far as one can understand the coke industry is not yet in a condition to dictate higher prices for furnace coke, and may not be until a good many more furnaces are blowing. It is said that in Cleveland there is to be an increase in the number of furnaces, and recent sales of Cleveland iron seem to have reduced the reserves very considerably; but in the Midlands there is as yet no positive information as to the re-starting of the idle furnaces, although it is thought that two of the Lincolnshire furnaces may be started again early in the New Year. The fact is that Lincolnshire iron is rather scarce here, and although nine out of ten ironfounders do not care so long as there is plenty of Derbyshire, the tenth will sometimes want a little Lincolnshire, and recently from 3s. to 3s. 6d. per ton more than the price of Derbyshire was paid for it. For Derbyshire No. 3 the usual price here is 90s. delivered, and perhaps a fraction less may be taken for Northamptonshire. Scotch iron remains very steady at 107s. 6d. delivered here and the demand for it is not great.

Steel.

The feeling in the market for steel is perhaps not so confident as that in the crude iron market, but sellers here are fully expecting that trade will improve in the New Year. Meanwhile many of the steel works are short of specifications, even where they have contracts to fulfil, and the result is an eagerness to pick up orders and a disposition to cut the price, especially for straight lots of 50 to 100 tons of one section. For these lots in angles or joists possibly under £9 per ton would be quoted in Manchester. For plates the quotation is still £9 15s. to £10, and for round bars £10 5s. to £10 7s. 6d. Manufactured iron is rather dull and neglected, and the high price stands in the way of much business.

Scrap.

There is little movement in the scrap iron market yet, but the feeling amongst dealers seems to be rather more cheerful. The Sheffield buyers of steel scrap for melting purposes still stand out against paying more than 75s. per ton delivered, and dealers here are not satisfied

with the figure, although some of them accept it. The utmost buying price for this class of scrap at a Lancashire station is 65s., and some dealers do not offer more than 62s. 6d. Those ironfounders who make a practice of mixing much small steel scrap with their metal in the cupola ought to be satisfied with the price at which they can buy it. Wrought scrap is dull and neglected at about 80s., although for really good lots dealers try to get 85s. per ton, delivered at the forges. In cast scrap there is a small business passing at 80s. for ordinary qualities, and up to 85s. for textile. The ironfounders are, however, not buying very freely. In this department of the scrap trade hopes are built upon the probable improvement in the demand for castings next year.

Oil versus Steam Engines.

The internal combustion engine has been very much to the fore in discussions which have taken place in Manchester during the last few days. The report of the joint committee of the Institutions of Mechanical Engineers and Naval Architects on the Sycamore trials, which was read in abstract by Mr. S. B. Freeman at the meeting of the North-Western Branch of the first mentioned society, gave rise to an excellent debate. The Manchester and District Association of the Institution of Civil Engineers showed its interest in the subject when a paper by Mr. J. A. Chippindale, Student, Inst. C.E., was given on Wednesday last on this type of prime mover applied to civil engineering construction. The author pointed out the advantages of the oil engine for supplying the motive power for the many kinds of appliances used by civil engineers, such as cranes, winches, pumps, air compressors, pile drivers, excavators, &c. He emphasised the fact that with the internal combustion engine stand-by losses were eliminated and no carrying had to be done for the removal of cinders, as with the usual steam plants, while both in simplicity and first cost the oil engine scored over that using steam. He said that under practical working conditions it had been conclusively proved that the attention required by the heavy oil engine was only one-third of that required by steam plants, which item alone was sufficient to reduce materially the contractor's power costs.

BARROW-IN-FURNESS.

Hematite.

The condition of the hematite pig iron trade slowly improves, and as evidence of this the Millom and Askam Company has put in another furnace. There are now fourteen in blast in the district, which shows that some of the makers have practically cleared the stocks they had in hand. Barrow and Workington rail mills are now taking more iron, Barrow particularly. There is a tendency to place orders for delivery well into next year and there are more inquiries. The present trade is not heavy by any means, but it is shaping towards a better condition, and it is no worse for developing slowly. It will last all the longer. Business in better qualities of iron promises to be better. The trade with the Continent does not bulk largely at present, and the American business is not extensive, but there are possibilities as regards the latter.

Iron Ore.

The position in the iron ore trade has improved to some extent, the putting in of more furnaces naturally helping the position. The demand for native ores from outside the district is not great, but there are hopes of it increasing in the future. Foreign ores are in slightly better demand and will improve as the iron trade enlarges.

Steel.

The steel trade remains the same. There is no news yet of any fresh orders for either Cumberland or Barrow, but the outlook is not so bleak as it has been. The Workington rail mills are working this week, and the Barrow rail mills are likely to run into next year with the orders at present held. The wire and small sections departments are fairly well situated for orders. Foundries are experiencing slightly better business.

Shipbuilding and Engineering.

A deputation which waited upon Mr. Neville Chamberlain regarding the repayment of loans by the Barrow Board of Guardians got very little comfort out of the Minister as regards the repayment, but he assured them that Barrow was in for better times, and there are those in Barrow who deduce that the Government will not forget them when the orders for the new cruisers are given out. Barrow is also hoping that it may get the order for one of the Australian cruisers which were referred to last week.

SHEFFIELD.

(From our own Correspondent.)

The Heavy Steel Trade.

As the year draws towards a close, there is a quietening down of several branches of the steel trade. This does not necessarily indicate a falling off in work to be placed, but may be to a large extent connected with stocktaking. There is a good deal of confidence in what the New Year may bring forth, and even at present numbers of firms are booking orders on an increasing scale. The slackness is most apparent on the semi-finished side of the trade, which is finding a reduced call for billets. The steel foundries and forges have not much heavy work on hand, but there is a moderate demand for castings and forgings of medium weight. There has lately been a considerable increase in the volume of orders from the engineering and shipbuilding branches; in fact, the quantity of Sheffield material going into engineering at present is higher than at any time during the year. The agricultural section is unsatisfactory, however, and steam engine builders are only doing fairly well. The machine tool trade is quiet.

Railway Material.

Many good orders for railway material were announced last week-end by the London and North-Eastern and the London, Midland and Scottish companies, and a fair proportion of them will come to Sheffield or to firms connected with the city. The London and North-Eastern Railway Company programme for 1925 will involve an expenditure of 6 millions on new rails, locomotives, carriages, and wagons, and Sheffield should benefit in each of these sections. The actual allocation of contracts, as published at present, relates mainly to wagons, of which good quantities are to be obtained from firms in Sheffield, Rotherham, Lincoln, Chesterfield and other places in the district, as well as from Birmingham works which are amalgamated with leading Sheffield companies. The programme should also bring a welcome amount of work to the Sheffield manufacturers of locomotive tubes, who are already well employed. Further, it may be assumed that the axle, tire and spring departments, which are among the most important in the heavy steel trade, will receive considerable new orders as a result of the policy of stock renewal. These branches have been better off for work during the past year than they were in the preceding twelve months, but they have not been fully employed, and their capacity is so great that a vast amount of work is required to keep them in constant operation.

The Lighter Side.

Many of the makers of tool steel are only able to report an indifferent trade, but on the whole the year has shown an improvement, and has been the best since 1921. Orders are coming in from a wider range of markets, and some of the larger firms, which are closely in touch with overseas buyers, have been doing better lately. Trade with the Continent is on a limited scale, but is showing expansion. On all hands, there are evidences of the desire of European engineers to return to the use of high-class Sheffield steel, but financial difficulties prevent a rapid growth of the demand. Hack saw sheets made of crucible steel are in good request, and there is also a healthy sale for manufactured hack saws. The magnet trade is in a brisk state, and is securing much new business from the manufacturers of wireless appliances. A good demand for machine knives is reported, but the general state of the engineers' tools trade is quiet, although a few firms have good order books. For joiners' and some other varieties of edge tools, there is a demand just about sufficient to meet the output, but increase of production is impeded by the scarcity of skilled men. The saw trade continues well employed. It is not so busy as it was early in the year, when boom conditions prevailed, but it has shown an increasing tendency recently. Australia, Scandinavia and other markets are taking large quantities of Sheffield-made circular saws for wood cutting. A good home demand exists for metal and wood-cutting circular saws, as well as band saws. A lecturer before the Sheffield Tool Trades' Technical Society last week appealed to the trade to take up the manufacture of the wide band saw, which, he said, had a great future. The use of such saws in the timber industry is rapidly extending.

Cutlery and Plate.

The seasonal orders for cutlery and plate have tapered off considerably, and several firms report that they have finished their special Christmas work. In case goods and cheap lines generally, however, there is still a large amount of activity, with orders continuing to come in, and firms who specialise in these respects will be busy for another week or two. There is a continued large demand for stainless steel cutlery, but it is to such a great extent for the cheap article that many of the old-established houses will not entertain the business. Several of the good-sized firms are, however, now entering into competition with the little masters, and are offering the goods at very low prices. A good quantity of first-class hollow-ware is being produced for hotel and steamship equipment, but the trade generally, apart from these orders, is quiet.

Trackless Trams for Chesterfield.

I have previously referred to the probability of a change in the system of public transport at Chesterfield, and now the Town Council has decided to make that change by adopting trackless trolley vehicles in place of the present tramcars. The Tramways Committee brought up a recommendation to this effect at last week's Council meeting, and it was carried—against an amendment to refer the matter back—by 24 votes to 20. A sub-committee was appointed to prepare a scheme. The chairman of the Tramways Committee, in introducing the recommendation, said that it was in accordance with the report of Mr. A. Baker, manager of the Birmingham tramways, after inspecting the present system. The Committee felt that railless vehicles would give the best transport system. Mr. Baker reported that the tramways were worn out, and that, although they could be given a further three or four years' life by an expenditure of £4000, the outlay would be bad economy. It would cost £50,300 to reconstruct the present track, while to double it would mean an outlay of £100,000. The Committee did not favour any such expenditure, but recommended trolley omnibuses as being safer, quicker and cheaper. Pointing to the existence of the overhead tram equipment as being suitable to trolley vehicles, he said that that equipment was in a very good state and was largely paid for. Evidence showed that trolley omnibuses were run at 2d. less per mile than petrol omnibuses. The present tram mileage was 300,000 per year, while railless vehicles would run 375,000 miles per year.

Two New Schemes.

The Water Committee of Sheffield City Council recommends the expenditure of £70,070 on the provision of a 12in. duplicate main from Ringinglow to Woodhouse Mill, a distance of 13 miles, for a supply of water to Kiveton Park and Rotherham Rural District Council. Rotherham Corporation has decided upon the building of a new bridge over the river Don, close to the historic Chantry Bridge, which carries an old chapel and has been scheduled as an ancient monument. The new bridge will be of concrete, with an 80ft. clear span; will be 60ft. wide, and will have a 36ft. carriageway. It will cost £90,000, of which half will be contributed by the Ministry of Transport and the Unemployment Grants Committee.

Vickers' Airship Order.

The preparations for the building of a giant airship of 5,000,000 cubic feet capacity by Vickers Limited are proceeding. Officials of the firm have during the last few days visited Howden airship base, East Yorkshire, where the huge vessel is to be assembled. It is understood that arrangements have been practically completed to take over the necessary land in the vicinity of the twin airship shed, and that the Airship Guarantee Company—an associate company of Messrs. Vickers—took formal possession of the base on the 1st inst. Practically every other building with the exception of the twin shed has been demolished. The extension of the shed is under consideration, and the construction of new buildings and workshops will be started, it is expected, in the early spring.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Iron Trade.

THE Cleveland pig iron market has assumed a quieter turn, and business all round is slower. It is no unusual phenomenon at this time of the year, and the feeling of confidence which entered the market a week or two ago is well maintained. Indeed, the prevailing opinion is that there is more reason than ever to expect gradual development towards re-establishment of normal conditions. But until the Christmas holidays are over works are not disposed to commit themselves further, being already well covered for immediate needs. Most continental producers maintain their quotations, but one or two firms are understood to have made price concessions to secure orders, and doubt is expressed in this district of manufacturers abroad continuing to quote as at present. Thus there is some threat of continental competition again becoming rather keen. With regard to the export trade, there has been no expansion as the firmer prices asked by continental producers are not expected to endure, and buyers are consequently holding off. The possibilities of the United States as an outlet for any surplus iron are distinctly hopeful, however. No more local iron has been sold for Transatlantic shipment, but there have been inquiries for both foundry and East Coast hematite pig iron, and some of them may mature. Hopeful feeling as regards the future is emphasised by the disinclination of makers to commit themselves heavily ahead, while preparations are proceeding for the re-starting of one or two idle blast-furnaces, but there seems little likelihood of plant being rekindled until the New Year. Prices are easier. In some cases 82s. per ton is still asked for No. 3 G.M.B. Cleveland pig iron, but business has also been done at 81s. 6d. No. 1 is firm at 87s., but possibly 81s. for No. 4 foundry and 80s. for No. 4 forge might also be shaded.

Hematite Pig Iron.

There are no new features of moment in the East Coast hematite pig iron trade. Makers have fairly good order books, but new business is coming forward very slowly. Mixed numbers range from 88s. to 89s. per ton, according to brand, No. 1 in all cases being 6d. per ton more.

Ironmaking Materials.

Another quiet period has been entered upon by the foreign ore trade. Works seem to have all the supplies they need, and only come on to the market for odd cargoes to make up their accustomed mixtures. The price of best Rubio ore is nominally 22s. 6d. per ton c.i.f. Tees. Good Durham furnace coke is still kept at 25s. per ton delivered at the works.

Manufactured Iron and Steel.

Although business has improved considerably in the manufactured iron and steel trade, the works are not running at full pressure, and further orders would be welcome. Continental buying is little heard of, but rather good colonial inquiries are coming forward, and one or two contracts have been arranged. With few orders coming forward for steamers, shipbuilding requisites are only in moderate request, but railway material and constructional material are selling fairly well. Prices are unchanged.

The Coal Trade.

There is no great alteration apparent in any direction in the Northern coal trade. The demand as a rule is only quiet, and though there are said to be a number of inquiries in circulation, they are more or less in the nature of feelers, as the trade in hand or in prospect is as yet not nearly sufficient to absorb the output of the collieries, and though some of the Northumberland steam coal producers are well stemmed for the present, other fitters in Durham are not so well situated. The success of German tenders to the French State Railways rather disturbs the forward outlook, as merchants realise that for a considerable time they will have to meet very keen competition from that source, so that the outlook for the winter months is not regarded with any great confidence. Americans are also competing keenly, and have succeeded in securing one or two orders from Italy during the past few days by under-cutting Durham coal prices. There is still considerable divergence in the ideas of buyers and collieries as to prices. Buyers state that ultimately prices will yield somewhat, but many collieries seem determined, rather than risk further loss, to close down. Many of the collieries have been working at a loss for some months, and when present contracts have finished they may, in face of the current quotations, come to a stoppage. Best steams

are quoted from 18s. 6d. to 19s. 6d., and from 22s. to 23s. for Durham screened steams. Gas coal prices are unchanged, and range at about 22s. to 22s. 6d. and 18s. for secondary sorts. Coking coals are steadier at from 18s. to 18s. 6d. for the usual well-known brands. The coke position is a trifle firmer, and as the demand is somewhat accelerated, the prices have stiffened for patent oven foundry, which is at about 23s. to 25s., and 30s. to 35s. for beehive.

SCOTLAND.

(From our own Correspondent.)

Markets Quiet.

PRACTICALLY nothing of a fresh nature has been reported during the past week. A little more activity has been reported here and there, which is chiefly due to the approach of the holidays. Unless something unforeseen occurs no change in general conditions will take place until after the turn of the year.

Brighter Outlook.

Within recent years the position at a similar period has so often been as it is to-day that forecasting seems almost futile. On this occasion, however, it may be said that the "hopeful feeling" is very strong. The tone in the various markets continues to improve, and a broadening out in business generally is anticipated early in the New Year. Makers appear more confident that continental competition can be successfully met, and hope to gain a considerable proportion of the orders which must eventually emanate from shipyards and engineering shops. In some directions, too, the export outlook is better. Some products which have long ceased to have interest to exporters are again being inquired for, and while nothing much in the way of business may materialise just immediately, the fact is encouraging.

Pig Iron.

The pig iron market remains fairly steady. The demand from steel works is a trifle slow, but foundry shows some improvement. Prices are firm, without any indication of appreciating meantime. The export inquiry has been a shade more active of late. The output is not yet taxed, but stocks are gradually decreasing.

Steel and Iron.

The market holds little of fresh interest so far as steel plates and sections are concerned. As has been already mentioned above, shipyard orders are bound to be in circulation soon, and if makers could only reduce the margin between their own and continental prices still further, the future would be quite promising. Quotations for local delivery are unchanged. Makers of thin sheets are securing all the business they can tackle, and in some cases are sold well ahead. Galvanised sheets are very firm, £18 10s. per ton f.o.b. Glasgow being mentioned for 24 b.g. Heavy sheets improve slowly. Bar iron remains rather poorly supported. Apart from some small lots for engineers and wagon builders very little business is passing, and plants move very slowly. The same may be said of re-rolled steel products. More movement in scrap material is reported, not only for immediate use but also for delivery over the next three months.

Coal.

The situation in the coal trade is unaltered. Lanarkshire splints maintain a firm attitude due to recent buying for shipment to Italy and the River Plate, but the little increase in business noticeable in other descriptions is chiefly due to consumers making provision over the holidays. Lanarkshire ells are a shade firmer, and steams from both Fifeshire and the Lothians find a better outlet. Single nuts, pearls, and to a lesser degree double nuts, in all districts move freely, but treble nuts are barely steady. A firmer tone in prices is largely accounted for by the oversold nature of the collieries consequent on greatly reduced outputs. Aggregate shipments for the past week amounted to 275,449 tons, against 263,898 tons in the preceding year, and 292,346 tons in the same week last year. Practically all business is for immediate delivery, forward transactions being still conspicuously absent. The home market is only moderately active. Industrial demands continue below normal, while mild weather curtails household requirements.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Outlook.

THE best that can be said of the steam coal trade is that the market is well maintained, and promises to continue so to the end of the year at least. Some of the special grades of superior qualities are stronger, and are worth as much as 27s. 9d., but there is very little change in other directions so far as prices are concerned. On the whole, most of the collieries are rather better off for prompt orders than they were recently, but at the same time they are not pressed except in isolated cases. The foreign inquiry does not give a great deal of encouragement, so far as the future is concerned, and there is no doubt that quite a number of orders would have come to this district but for the severe German competition which is being experienced. Instances have been known of late in which very low prices quoted for Welsh coals have been cut out by Germans to the extent of several shillings per ton. So far, no definite news has been received regarding the placing of the Egyptian State Railways' contract for 200,000 tons of large qualities. Some of the prices sent in were known last week, but the tenders had to hold good for ten days as from the 3rd inst., so that something should be known before the end of this week. It will be a big surprise if on the basis of the quotations put in the business does not come to this district. A little more contracting has been done over next year on the part of exporters with the collieries, apart from which the French State Railways have purchased about 50,000 tons of smalls for delivery over the first few months of next year at the price of 17s. 6d. c.i.f. North French ports and 18s. c.i.f. French Bay ports. These are regarded as very low prices, involving more risk than the average exporter is prepared to face, especially as sellers have to give guaranteed analysis and are subject to penalties, which make the business somewhat onerous.

Coalfield Items.

Anthracite miners at a meeting at Swansea on Saturday last passed a resolution that no collier should work overtime on the coal during the week or the week-end. Work ceased on Saturday last at the Graham Navigation Colliery, Sirhowy, the notices to the workmen having expired on the previous Thursday. There appears to be no prospect of the colliery resuming in the immediate future. This means an addition of about 600 men to the unemployed list. A ban on overtime has also been placed on collieries by a meeting of the Monmouthshire Western Valleys Miners' Council. It was expected that a resumption of work would take place in the early part of this week at the Beynon pit, Blaina, which is owned by the Ebbw Vale Company. The pit has been idle some time, but has been kept in good order, so that it is hoped that about 1500 men would find employment at once. Sinking operations at the Steer pit, Gwaun-cae-Gurwen, have now been completed by Messrs. Guest, Keen and Nettlefolds, this being where the seam known as the Middle Vein has been struck. This is the first of a number of lower seams which the company proposes to work at the pit, and which it is hoped to develop, so as to obtain an output of 4000 tons per week. The present production of the East and Maerdy pits, Gwaun-cae-Gurwen, is round about 6000 tons weekly.

Miners' Wages.

Reference was made briefly last week to the audit for the month of October, and the fact that the wages of the miners in this district for the current month would again remain at the minimum of 42.22 per cent. on the 1915 standard rates, inasmuch as the wages certified worked out at the percentage of 15.55, which compares with 17.6 per cent. for September. Since the existing agreement came into operation—that is, from June to October inclusive—the loss on production has amounted to £737,170, which is equivalent to £1,770,000 per annum. Taking the figures for October, the cost of production in the South Wales coalfield was practically 8s. per ton greater than the cost in 1913, and of that 8s. wages accounted for 5s. 6d. apart from the additional 8d. per ton due to the extra benefits now received by the miners under the health and unemployment insurance, welfare and other schemes.

Engineering Exhibition.

The engineering exhibition organised by the South Wales Institute of Engineers at Cardiff, which came to an end last Saturday, was an unqualified success. Colliery managers were much in evidence on the closing day, and were welcomed by the President (Mr. W. A. Chaman) and members of the Council. In the course of the proceedings, Mr. H. Spence Thomas said that that was their third venture, and to launch it forth required a great deal of courage on the part of the promoters. But they had been fully justified, and had decided to hold another exhibition next year. Not only that, but the Council had decided to hold a similar exhibition, but of a more general character, at Swansea next August. At that exhibition there would be shown machinery applicable to the metallurgical and mining industries in the western portion of the coalfield. The Council had come to this decision in view of the great advancement made in the Swansea district, and particularly the development of the anthracite industry, which was the only bright spot in the Welsh coalfield.

Steelwork Contract.

The contract for the steelwork required in the construction of the viaduct over the river Taff, near Merthyr Station, has been secured by Sir William Arrol and Co., Limited, of King's Dock, Swansea, where the work will be carried out. The value of this section of the work is about £10,000.

Current Business.

Although there has not been a great deal of fresh business about on the market, the tone continues to be steady in all departments. Most of the collieries are fairly well booked up for the remainder of this month, and provided tonnage turns up as arranged, shipments should be continued fairly regularly, thus enabling the pits to work without interruption. On the whole, prices have not undergone much, if any, alteration, but a feature of the market is the sharp upward movement which has taken place in pitwood for prompt delivery. Some of the collieries have been caught short of supplies, with the consequence that the price has advanced to 32s. 6d.

Tin-plate Trade.

On Friday of this week the Stabilisation (Prices) Committee again meets, and its proceedings are invested with more than ordinary interest, as apart from the question of the merchants' commission being down for consideration, it is understood that the whole question of the continuance or otherwise of the stabilisation scheme itself will be reviewed.

Pits to Re-open.

It is understood that there is a good prospect of the Ebbw Vale Company re-opening its Vivian and Tillery pits at Abertillery very shortly. They were closed down about two months ago on account of trade depression.

Catalogues.

HENRY RUSSELL AND CO., Limited, Waverley Works, Sheffield.—New milling cutter price list.

BEECROFT AND PARTNERS, Limited, St. Peter's Close, Sheffield.—Booklet entitled "Chemist and Founder."

EWART AND SON, Limited, 346–350, Euston-road, N.W. 1.—Brochure on Ewart's Emperor cowl.

BROOM AND WADE, Limited, High Wycombe.—Brochure on the "Broomaster" portable compressor.

MANLOVE, ALLIOTT AND CO., Limited, Nottingham.—Sheet No. 5579 on Manlove's laundry requisites.

HAYWARD COMPANY, 62, Red Lion-street, Clerkenwell-road, E.C. 1.—Brochure on the "Realhandy" clip.

NORTON COMPANY, Worcester, Mass., U.S.A.—Booklet on "Factors Affecting Grinding Wheel Selection."

ED. BENNIS AND CO., Limited, Little Hulton, Bolton.—A descriptive catalogue on the Bennis chain grate stoker.

DOWDINGS' MACHINE TOOL COMPANY, Bush House, Aldwych, W.C. 2.—Two leaflets on the Dowdings' machine tool registry.

GENERAL ELECTRIC COMPANY, Limited, Magnet House, Kingsway, W.C. 2.—A new switchboard catalogue, Section X (1).

MIDGLEY AND SUTCLIFFE, "Richmond" Tool Works, Bradford.—A new list of the "Richmond" universal milling machines.

WESTERN ELECTRIC COMPANY, Limited, Connaught House, Aldwych, W.C. 2.—Booklet entitled "The World's Messengers."

BRITISH STEEL PILING COMPANY, Limited, 54A, Parliament-street, S.W. 1.—A catalogue on the Vibro cast-*in situ* concrete piles.

FOSTER ENGINEERING COMPANY, Limited, Morden Works, S.W. 19.—Illustrated leaflet L 60, on lanterns for gas-filled lamps.

ERNEST J. BATY, 157, Dunstable-road, Luton.—Two leaflets on "Baty's Components and Receivers" and "Proved by the Test."

THOMAS WILSON, SON AND CO., 34, St. Andrew-square, Edinburgh.—An illustrated catalogue, "Test Borings" on land or water.

MATHER AND PLATT, Limited, Park Works, Manchester.—Publication P. 46, dealing with centrifugal hydraulic pressure pumps.

THE COVENTRY CHAIN COMPANY, Limited, Coventry.—Booklet CV/1 relating to the "Coventry" heavy roller chains for service vehicles.

A. REYROLLE AND CO., Limited, Hebburn-on-Tyne.—A book reproducing various technical journals' reviews on Reyrolle switchgear.

BRITISH INSULATED AND HELSBY CABLES, Limited, Prescot, Lancashire.—P 189, a general descriptive catalogue for electrical contractors.

J. H. HEATHMAN, Limited, Parsons Green, S.W. 6.—A number of leaflets on "Heathman" appliances for fighting and protection against fire.

THE ARMCO INTERNATIONAL CORPORATION, Pinners' Hall, Old Broad-street, E.C. 2.—Booklet entitled "'Armco' Ingot Iron Facts."

MIRRLEES-WATSON COMPANY, Limited, Scotland-street, Glasgow.—Catalogue Pu. 700 on "Centrifugal Pumps for low and medium lifts."

JAMES KEITH AND BLACKMAN COMPANY, Limited, 27, Farringdon-avenue, E.C. 4.—Booklet V81 on gas boosting and exhausting fans.

J. W. BROOKE AND CO., Limited, Adrian Works, Lowestoft.—Leaflet describing the "Brooke" combined portable pumping and industrial sets.

STEAM FITTINGS COMPANY, Limited, West Drayton, Middlesex.—Leaflets describing the "Drayton" meter valve and "H.M." boiler valves.

JOHN I. THORNYCROFT AND CO., Limited, Thornycroft House, Smith-square, S.W. 1.—Publication M.M.D./1087, on the Thornycroft propeller.

AUTO-WELDING AND ENGINEERING COMPANY, Limited, 29A, Portpool-lane, Gray's Inn-road, E.C. 1.—Leaflet describing the "Zephyr" barrow.

PURIT SPECIALTIES, Limited, Park-street, Birmingham.—List No. 80, on the "Purit" electric gluepot, and a leaflet on the "D.L.S." electric fitting.

THE NATIONAL GAS ENGINE COMPANY, Limited, Ashton-under-Lyne.—Leaflet No. 55, illustrating and describing the National suction gas plants.

RAGESINE AND COMPANY, 161, Bow-road, E. 3.—A copy of the "Digest of Current Scientific Literature on Lubrication and Allied Problems, No. 6."

CAMBRIDGE INSTRUMENT COMPANY, Limited, 45, Grosvenor-place, S.W. 1.—Postcard illustrating the Cambridge pressure recorder, also card illustrating the use of the Cambridge optical pyrometer in a foundry.

Latest News from the Provinces.

WALES AND ADJOINING COUNTIES.

Egyptian State Railways.

THE order for 200,000 metric tons of large steam coals for the Egyptian State Railways, to be delivered over five months, January to May inclusive, at Alexandria, has been placed with two local firms, viz., W. Milburn and Co., 50,000 tons; and Watts, Watts and Co., 150,000 tons.

A NEW LEVEL INDICATOR.—In connection with the article on the new level indicator made by the Aster Engineering Company, which appeared in our issue of December 5th, the makers ask us to point out that the gauge is suitable for installation on closed, as well as open, tanks, and that the manometer operates independently of the pressure within the tank.

THE POLAR HEAVY OIL ENGINE—CORRECTION.—In our article describing the Polar heavy oil engine, published on page 648 of last week's issue, the crank case compression of the scavenging air was shown on the indicator diagram reproduced in Fig. 3 as 0.5 lb. per square inch. This should have read 5 lb. per square inch, which figure was given correctly in the text of the article.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
Native	17/6 to 24/-
(1) Spanish	23/-
(1) N. African	23/-
N.E. COAST—	
Native	—
Foreign (c.i.f.)	22.6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	4 15 0	—
No. 1 Foundry	4 15 0	—
No. 3 Foundry	4 10 0	—
N.E. COAST—		
Hematite Mixed Nos.	4 8 6	4 8 6
No. 1	4 9 0	4 9 0
Cleveland—		
No. 1	4 7 0	4 7 0
Silicious Iron	4 7 0	4 7 0
No. 3 G.M.B.	4 1 6 to 4 2 0	4 1 6 to 4 2 0
No. 4 Foundry	4 1 0	4 1 0
No. 4 Forge	4 0 0	4 0 0
Mottled	—	—
White	—	—
MIDLANDS—		
(3) Staffs.—		
All-mine (Cold Blast)	10 10 0	—
North Staffs. Forge	3 17 6	—
„ „ Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	3 17 0	—
„ Forge	3 11 0 to 3 12 0	
(3) Derbyshire—		
No. 3 Foundry	4 2 6	—
Forge	3 17 6	—
(3) Lincolnshire—		
No. 3 Foundry	4 2 6	—
No. 4 Forge	4 0 0	—
Basic	4 5 0	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	5 5 0 (a) / 5 10 0 (b)	—

MANUFACTURED IRON.

	Home. £ s. d	Export. £ s. d.
SCOTLAND—		
Crown Bars	12 0 0	—
Best „	—	—
N.E. COAST—		
Common Bars	12 0 0	—
LANCS.—		
Crown Bars	13 0 0	—
Second Quality Bars	12 0 0	—
Hoops	15 0 0	14 15 0
S. YORKS.—		
Crown Bars	13 0 0	—
Best „	13 10 0	—
Hoops	14 10 0	—
MIDLANDS—		
Crown Bars	12 15 0	—
Marked Bars (Staffs.)	15 0 0	—
Nut and Bolt Bars	11 15 0	—
Gas Tube Strip	13 5 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	13 0 0	—
Ship Plates, ¾in. and up	9 15 0	—
Sections	9 10 0	—
Steel Sheets, 3/16in. to ¾in.	12 0 0	—
Sheets (Gal. Cor. 24 B.G.)	—	18 10 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	9 15 0	—
Angles	9 10 0	—
Boiler Plates	13 0 0	—
Joists	9 10 0	—
Heavy Rails	9 0 0	—
Fish-plates	13 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	9 10 0	—
Soft Billets	8 10 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	9 0 0†	—
Light „	9 5 0 to 9 10 0	
Billets	8 0 0 to 11 10 0†	
MANCHESTER—		
Bars (Round)	10 0 0 to 10 10 0	
„ (others)	9 15 0 to 10 0 0	
Hoops (Best)	15 5 0	15 0 0
„ (Soft Steel)	13 15 0	13 10 0
Plates	9 15 0 to 10 0 0	
„ (Lancs. Boiler)	13 0 0	—
SHEFFIELD—		
Siemens Acid Billets	11 10 0	—
Bessemer Billets	13 0 0	—
Hard Basic	9 10 0	
Intermediate Basic	9 0 0	
Soft Basic	8 0 0 to 8 5 0	
Hoops	12 0 0	—
Soft Wire Rods	11 0 0 to 11 10 0	
MIDLANDS—		
Small Rolled Bars	9 5 0 to 10 0 0	
Billets and Sheet-bars	7 10 0 to 7 15 0	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	17 7 6 to 17 10 0	
Angles	9 5 0	—
Joists	9 5 0	—
Tees	10 5 0	—
Bridge and Tank Plates	9 15 0	—
Boiler Plates	13 10 0	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	23/6 to 23/7½
Block Tin (cash)	256 10 0
„ (three months)	259 12 6
Copper (cash)	63 18 3
„ (three months)	64 17 6
Spanish Lead (cash)	39 12 6
„ (three months)	37 12 6
Spelter (cash)	35 11 3
„ (three months)	35 11 3
MANCHESTER—	
Copper, Best Selected Ingots	70 0 0
„ Electrolytic	73 0 0
„ Strong Sheets	95 0 0
„ Tubes (Basis price)	0 1 1½
Brass Tubes (Basis price)	0 1 0
„ Condenser	0 1 2½
Lead, English	42 15 0
„ Foreign	41 5 0

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/8½ per lb.	
Ferro Tungsten	1/4½d. per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£24 0 0	8/-
„ 6 p.c. to 8 p.c. „	£23 10 0	7/9
„ 8 p.c. to 10 p.c. „	£23 0 0	7/6
„ Specially Refined		
„ Max. 2 p.c. carbon	£43 0 0	16/-
„ „ 1 p.c. „	£52 0 0	17/6
„ „ 0.75 p.c. carbon	£60 0 0	20/-
„ „ carbon free	1/5 per lb.	
Metallic Chromium	4/2 per lb.	
Ferro Manganese (per ton)	£15 for home, £15 for export	
„ Silicon, 45 p.c. to 50 p.c.	£11 15 0	scale 5/- per unit
„ „ 75 p.c.	£17 17 6	scale 6/- per unit
„ Vanadium	17/6 per lb.	
„ Molybdenum	7/9 per lb.	
„ Titanium (carbon free)	1/2 per lb.	
Nickel (per ton)	£165	
Cobalt	10/- per lb.	
Aluminium (per ton)	£130	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	16/9
„ „ Ell	18/9
„ „ Splint	20/- to 24/-
„ „ Trebles	19/6
„ „ Doubles	19/-
„ „ Singles	14/6
AYRSHIRE—	
(f.o.b. Ports)—Steam	16/9
„ „ Splint	20/-
„ „ Trebles	19/6
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	15/1½ to 17/9
Screened Navigation	25/-
Trebles	21/-
Doubles	19/-
Singles	15/-
LOTHIANS—	
(f.o.b. Leith)—Best Steam	18/-
Secondary Steam	17/-
Trebles	20/-
Doubles	19/6
Singles	14/-

ENGLAND.

(8) N.W. COAST—	
Steams	28/6
Household	45/- to 58/4
Coke	30/-
NORTHUMBERLAND—	
Best Steams	18/6 to 18/9
Second Steams	17/6 to 18/-
Steam Smalls	10/6 to 10/9
Unscreened	15/6 to 17/-
Household	23/6 to 25/-
DURHAM—	
Best Gas	21/6
Second	18/3 to 18/6
Household	23/6 to 25/-
Foundry Coke	23/- to 24/6
SHEFFIELD—	Inland.
Best Hand-picked Branch	32/- to 35/-
Barnsley Best Silkstone	26/- to 28/-
Derbyshire Best Brights	27/- to 32/-
„ „ House	24/- to 26/-
„ „ Large Nuts	22/6 to 25/-
„ „ Small	14/- to 16/-
Yorkshire Hards	20/6 to 23/-
Derbyshire „	20/6 to 22/6
Rough Slacks	9/6 to 12/-
Nutty „	8/6 to 10/6
Smalls	4/- to 6/6
Blast-furnace Coke (Inland)*	—
„ „ (Export) f.o.b.	21/6 to 22/6

(9) SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Smokeless Large	27/3 to 27/9
Second „ „	26/- to 27/-
Best Dry Large	27/- to 27/6
Ordinary Dry Large	24/- to 26/-
Best Black Vein Large	24/6 to 25/-
Western Valley „	23/6 to 24/6
Best Eastern Valley Large	23/6 to 24/6
Ordinary „ „	22/6 to 23/-
Best Steam Smalls	16/- to 18/-
Ordinary „	13/- to 15/-
Washed Nuts	22/- to 32/-
No. 3 Rhondda Large	27/- to 27/6
„ „ Smalls	19/- to 20/-
No. 2 „ Large	22/6 to 23/6
„ „ Through	18/- to 20/-
„ „ Smalls	11/- to 13/-
Foundry Coke (export)	40/- to 47/6
Furnace Coke (export)	27/6 to 32/6
Patent Fuel	25/6 to 27/-
Pitwood (ex ship)	32/- to 32/6
SWANSEA—	
Anthracite Coals	
Best Big Vein Large	47/6 to 50/-
Seconds	40/- to 45/-
Red Vein	34/- to 36/-
Machine-made Cobbles	59/- to 60/-
Nuts	55/- to 60/-
Beans	44/- to 45/-
Peas	19/- to 23/-
Breaker Duff	9/6 to 10/-
Rubbly Culm	11/9 to 12/3
Steam Coals:	
Large	22/6 to 23/6
Seconds	22/- to 22/6
Smalls	14/- to 16/-
Cargo Through	17/- to 19/-

(1) Delivered. (2) Not Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. * For blast furnaces only, 16/9, with fluctuations according to analysis; open market, round about 22/6 to 25/- at ovens. † Latest quotations available. (*a*) Delivered Sheffield or Glasgow. (*b*) Delivered Birmingham.

French Engineering Notes.

(From our Correspondent in Paris.)

German Negotiations.

THE negotiations being carried out between representatives of the French and German iron and steel industries with a view of coming to an arrangement which might be embodied in the forthcoming treaty of commerce are encountering many difficulties, by reason of the complicated situation involved by the situation of the Lorraine steel firms. If the increased duties that are to come into operation on January 1st next are applied to French iron and steel entering Germany, the natural market for the Lorraine products will be practically closed, and it will be quite impossible to dispose of the production in France, which can only absorb about one-half of the present total of eleven million tons a year. Having lost Lorraine, Germany must now import considerable quantities of iron and steel, and the French are naturally desirous of arranging for the supplies to be obtained from Lorraine. They are insisting upon a reduction of the German import duties. The Germans have so far declined to do this on the ground that they would have to grant the same privilege to other countries enjoying the most favoured nation treatment. They have offered to purchase a million tons a year, and they have also made it a condition of any arrangement that the foundation of a European cartel should be laid for regulating the iron and steel production. The French are favourable to some such organisation for adjusting the supply to the demand, but they cannot accept the German terms, especially as they do not provide a solution of the coke problem. Nevertheless, it is affirmed that there is promise of an early settlement on the return of the German delegates, who left for Berlin in order to reconsider the proposals in the light of the French objections. It is even stated that a final agreement may be come to in the course of next week.

Arsenals.

The decision of the present Government to revoke the order of the previous Government to suppress the arsenals, except those of Toulon and Brest, met with vigorous criticism during the debate in the Chamber of Deputies on the naval estimates. The failure of the arsenals to justify their existence has been so repeatedly proved that the decision to maintain them appeared incomprehensible. It is true that the Minister of the Marine declared his intention of running the arsenals on industrial lines, but experience with other State administrations shows that it is extremely difficult to realise reforms against the force of inertia. It is admitted that the money spent upon the arsenals is out of all proportion to the value of the fleet. It was argued during the debate that it was impossible to develop the navy sufficiently while so much waste was going on in the arsenals and that a larger number of vessels could be constructed in private shipyards for the money now spent in the State establishments. Seeing, however, that the maintenance of the arsenals is a matter of principle with the present Government, there is very little chance of those who are agitating for the suppression of the arsenals as a means of economy obtaining satisfaction.

Automatic Couplings.

The question of fitting automatic couplings to railway coaches has again been receiving attention. It is argued that Government has no authority to impose any type of coupling without the advice of the Office Central d'Études du Matériel de Chemin de Fer. That body is so far from having a settled opinion on the matter that it recommended the carrying out of further tests in the coming spring. The trials were authorised by the Government, and they are to be continued for three months under the supervision of representatives of all the railways and of the different services interested. It is difficult to see how the Government can impose the Boirault apparatus before the trials are completed. So far the only two systems in competition have been the Boirault and the Henricot, but it is probable that others will be presented at the forthcoming trials.

Sahara Motor Traffic.

After the successful experiments in traversing the Sahara with various types of motor vehicles, particularly the six-wheeled Renault and the Citroën-Kégresse endless track car, it is perhaps not surprising that Monsieur André Citroën should have decided to organise regular services between Algeria and the river Niger. A company has been formed to run two services each way every week between Colomb-Béchar and Timbuctoo. The distance between the two towns is 1690 miles. The journey will be accomplished in nine days, mainly by ordinary wheeled cars, and only on two stages will the endless track vehicle be employed. The Niger will be reached at the town of Gao, and the last stage to Timbuctoo—a distance of 310 miles—will be accomplished by motor boats.

Port of Algiers.

Although the work of extending the port of Algiers should have been started upon a year ago, nothing has been done beyond equipping the neighbouring quarries and making other preparations, but it is expected that operations will be started shortly upon an enterprise which has to be completed within a period of eight years. Since then the Chamber of Commerce has elaborated the original programme, which now provides for a series of works down to the end of 1938. The estimated cost is 153,600,000f. The existing jetty is to be lengthened 400 m. and a new one 700 m. long is to be constructed. By the construction of the vast Mustapha basin and coal wharves of considerable area Algiers will become one of the largest commercial ports in North Africa. The contracts are being executed by Schneider and Cie., of Creusot, the Société Hersent, and the Etablissements Daydé.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

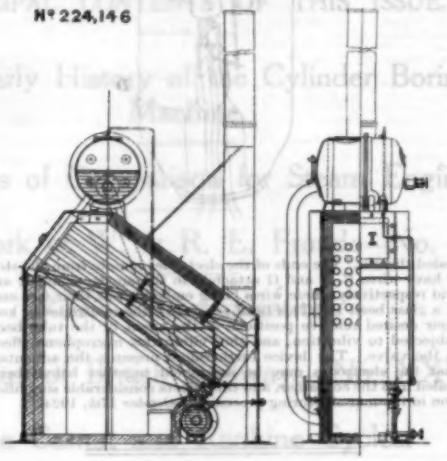
Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

224,146. March 11th, 1924.—WATER-TUBE BOILERS, J. Kerr-Book, K. A. Spearing, and the Vickers-Spearing Boiler Company, Bank Buildings, Kingsway, London.

This form of boiler is said to be specially applicable to relatively small capacities and to cases in which the boiler is built in sections for assembly at the place of installation. It is of the

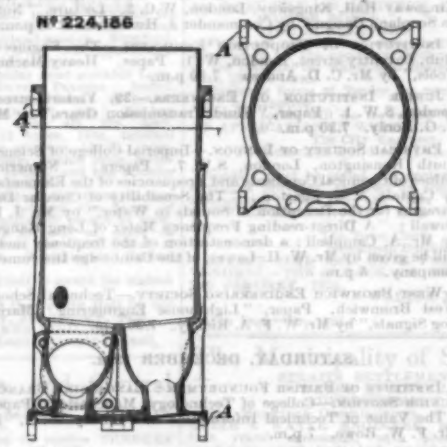


Spearing type, but the water tubes are arranged at a greater inclination than usual to increase the height of the combustion chamber, and the usual downcomer connecting the top and bottom drums is arranged outside the boiler casing to enable the dimensions of the latter to be still further reduced.—*November 6th, 1924.*

INTERNAL COMBUSTION ENGINES.

224,186. June 18th, 1924.—CYLINDER BLOCKS, M. S. Napier, Villa des Cistes, Chemin du Roi Albert, Cannes, France; and G. S. Wilkinson, 211, Acton-vale, London, W. 3.

It is claimed for this construction of cylinder that it is specially suitable for aircraft. Each cylinder comprises a head and a barrel formed as a unit, preferably by forging, and surrounded by a thin metal casing welded or otherwise connected thereto



in a water-tight manner to form a water jacket, lugs A A being provided on the cylinders outside or beyond the limits of the jacket by means of which each individual cylinder can be bolted to one or more similar cylinders to form a block. Such a block can be treated as a whole or any individual unit cylinder can be detached at will, there being separate short bolts for connecting each pair of adjacent lugs and hence no tendency for the structure as a whole to lose its rigidity.—*November 6th, 1924.*

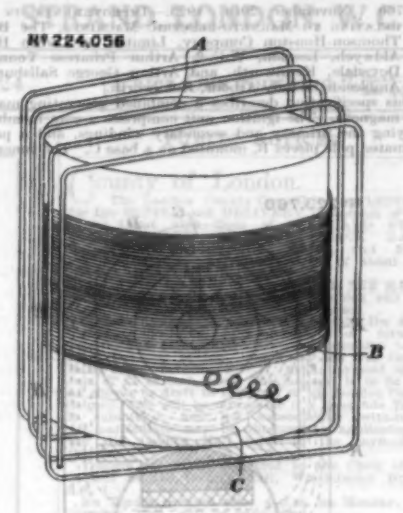
TELEGRAPHS AND TELEPHONES.

223,965. July 25th, 1923.—IMPROVED MEANS FOR SUPPORTING THE DIAPHRAGM OF A TELEPHONE TRANSMITTER OR RECEIVER, Henry Joseph Round, of 9, Woodberry-crescent, Muswell Hill.

One of the difficulties met with in obtaining a really accurate reproduction of sound is that of securing an aperiodic diaphragm. According to this invention with the exception of the middle part, which is exposed to the air, the diaphragm is damped. Preferably the damping is gradual, for otherwise reflection may occur at the place where an abrupt change in the damping occurs. In the case of a large flat diaphragm a coil is attached to the centre and this coil is placed in a magnetic field which sets the diaphragm in vibration or alternatively it produces an electromotive force when the diaphragm is set in vibration by sound waves. In the case of a strip diaphragm a middle portion of the strip may be left exposed to the air, whilst the remainder is insulated from the sound waves and is immersed in a damping medium such as cotton wool or felt. In general the total area of the diaphragm must be large as compared with the area exposed to the air in order that the damping shall not be abrupt, and the total damping shall be sufficient. As the inertia of the diaphragm must be small, the diaphragm is made thin.—*October 27th, 1924.*

224,036. October 1st, 1923.—IMPROVEMENTS IN FRAME AERIALS FOR WIRELESS TELEPHONY AND THE LIKE, Henry William Cole, of 14, Victoria-street, Westminster.

The construction of the frame aerial described in this specification will readily be understood from the accompanying drawing.

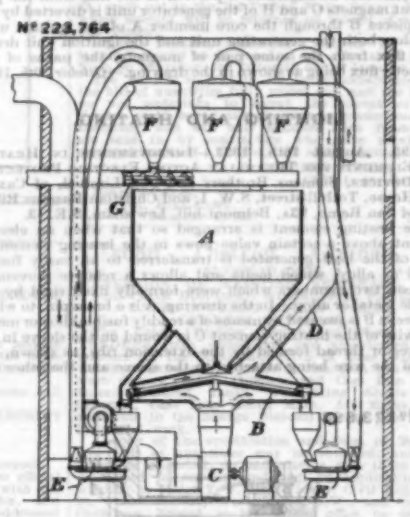


It consists of a non-directional system with two frame aerials or sets of windings, the wire of the inner section being wound in a manner different from that of the outer section. A is the wiring of the outer section or frame, and B the wiring of the inner section, C is the former on which the inner coil is wound.—*November 6th, 1924.*

FURNACES.

223,764. November 27th, 1923.—DRYING AND PULVERISING FUEL, The Underfeed Stoker Company, Limited, and W. R. Wood, Aldwych House, Aldwych, London, W.C. 2.

This invention comprises a bunker, distributor and dryer for powdered fuel. The coarsely ground fuel is stored in the hopper

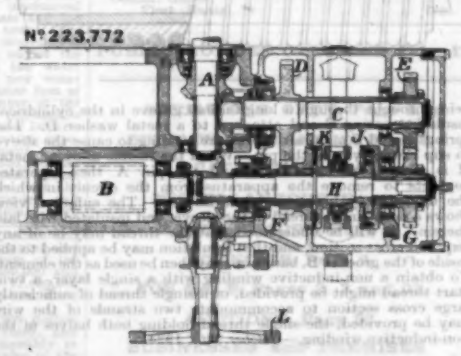


A and falls through a valve in the bottom on to the dished plate B, above which there works a rotary rake. Hot products of combustion are supplied under the plate B by a fan C, and escape by the flue D. The dried fuel falls into pulverisers E E, and is delivered to the cyclones F F by fans. The powdered fuel is taken to the furnace by a conveyor G.—*October 30th, 1924.*

MACHINE TOOLS AND SHOP APPLIANCES.

223,772. December 13th, 1923.—QUICK-RETURN MOTIONS, The Gear Grinding Company, Limited, H. F. L. Orcutt and J. W. Snarry, Ann-road, Handsworth, Birmingham.

In this quick-return gear the driving shaft is marked A, while the worm B is used to work the slide through any convenient



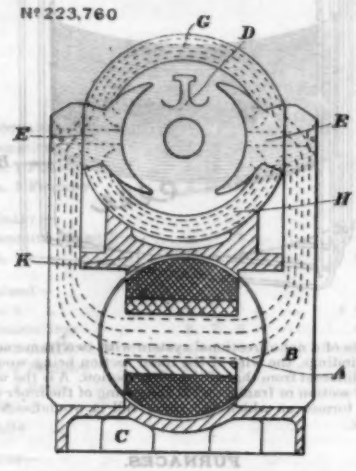
mechanism, such as a crank. The shaft A drives another shaft C, through bevel gearing, and on this shaft there are keyed two toothed wheels D and E. These wheels mesh with others F and G on the shaft H, and give different speed ratios. The wheel G is connected with the shaft H by a free-wheel clutch J, while the wheel F drives the shaft H through a friction clutch K. The

two wheels E and G provide the slow-cutting stroke, at the end of which the friction clutch K is brought into action. During the faster return stroke, the free-wheel clutch J over-runs the gear wheel G. The wheel L is used for hand feeding.—*October 30th*, 1924.

MOTOR CARS AND ROAD TRAFFIC.

223,760. November 20th, 1923.—IMPROVEMENTS IN AND RELATING TO MAGNETO-ELECTRIC MACHINES. The British Thomson-Houston Company, Limited, of Crown House, Aldwych, London, W.C. 2, Arthur Primrose Young, of Dovedale, Kenilworth, and Arthur George Salisbury, of Ambleside, Windy Arbour, Kenilworth.

This specification describes a combined generating machine and magneto. The ignition unit comprises a core member A, carrying the primary and secondary windings, and a pair of laminated pole pieces B, mounted on a base C. The generating

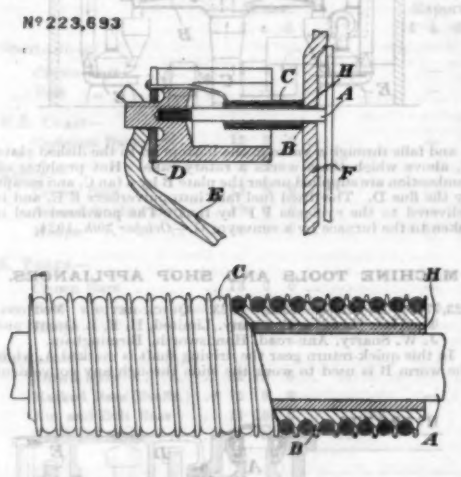


unit comprises a laminated armature core D and a pair of laminated pole pieces E, which are secured by screws or other means to the pole pieces B. Two permanent magnets G H are clamped to the pole pieces E. Non-magnetic material K is provided between the permanent magnet H and the pole pieces B. With this arrangement a portion of the flux from the permanent magnets G and H of the generator unit is diverted by the pole pieces B through the core member A of the ignition unit, and thus both the generating unit and the ignition unit derive their flux from the same pair of magnets, the paths of the magnetic flux being as shown in the drawing.—*October 30th*, 1924.

LIGHTING AND HEATING.

223,693. August 16th, 1923.—IMPROVEMENTS IN HEATING ELEMENTS FOR THERMALLY ACTING ELECTRIC PROTECTIVE DEVICES, Siemens Brothers and Co., Limited, of Caxton House, Tothill-street, S.W. 1, and Christian Rasmus Riber, of San Remo, 93A, Belmont-hill, Lewisham, S.E. 13.

The heating element is arranged so that when an electric current above a certain value flows in the heating element, a part of the heat generated is transferred to an easily fusible metal or alloy, which melts and allows a relative movement between two members which were formally fixed rigid by the fusible metal or alloy. In the drawing, A is a brass pin, to which the sleeve B is sweated by means of a readily fusible alloy or metal. The wire of the heating element C is wound on the sleeve in the grooves or thread formed by the extension ribs, as shown, one end of the wire being attached to the sleeve and the other end

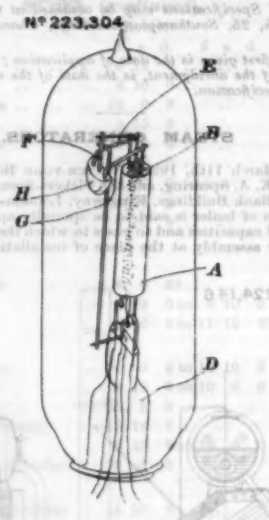


being brought through a longitudinal groove in the cylindrical insulating casing C and attached to a metal washer D. The springs E and F maintain a pressure tending to cause the sleeve to slip inwardly over the pin. When the fusible alloy or metal H is melted, motion occurs, and the pin A then operates contacts to remove the apparatus from the circuit in which the dangerously high current is flowing. The enlarged view shows a deep single thread in the sleeve, and insulated wire laid therein. It will be understood that the thread may be of any required cross-section, and that insulation may be applied to the inside of the grooves B, bare wire may then be used as the element. To obtain a non-inductive winding with a single layer, a two-start thread might be provided, or a single thread of sufficiently large cross section to accommodate two strands of the wire may be provided, the single thread holding both halves of the non-inductive winding.—*October 30th*, 1924.

MISCELLANEOUS.

223,304. July 17th, 1923.—IMPROVEMENTS IN AND RELATING TO THERMIONIC DISCHARGE TUBES, *The British Thomson-Houston Company, Limited, of Crown House, Aldwych.*

The object of this invention is to keep the desired spare relationships of the electrodes of a thermionic valve constant, both during the exhausting process and in the event of the tube being subjected to vibration. The electrodes are secured in the desired position by means of wires, which are attached to the free ends of the electrodes and are embedded in a glass or similar bend, which is independent of and is free to move relatively to the container. The construction will readily be understood from the accompanying drawing. The anode A, grid B, and filament C are all supported in the stem D by having their leading-in wires



sealed therein. The ends of the electrodes remote from the stem D have wires E, F and G attached to the anode, filament and grid respectively, these wires being embedded at their free ends in a glass bead H. This bead constrains the electrodes to keep their desired relative positions in the event of the tube being subjected to vibration, and thus eliminates microphone effects in the valve. The device furthermore presents the advantage that the electrodes may be assembled together before being sealed into the container, and this effects considerable simplification in the manufacturing processes.—*October 17th*, 1924.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

TO-DAY.

INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Metallurgical Department, University College, Singleton Park, Swansea. Discussion on "The Design of Furnaces for Annealing and Heat Treatment," to be opened by Mr. T. Hill. 7.15 p.m.

INSTITUTION OF AERONAUTICAL ENGINEERS.—Lecture Hall, Kingsway Hall, Kingsway, London, W.C. 2. Lecture, "Notes on Seaplane Design," by Commander J. Hunsaker. 6.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS.—The Engineers' Club, Coventry-street, London, W. 1. Paper, "Heavy Machine Tools," by Mr. C. D. Andrew. 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Paper, "Fluid Transmission Gears," by Mr. H. G. Bonly. 7.30 p.m.

PHYSICAL SOCIETY OF LONDON.—Imperial College of Science, South Kensington, London, S.W. 7. Papers: "Numerical Values of Chemical Constants and Frequencies of the Elements," by Captain A. C. Egerton; "The Sensibility of Circular Diaphragms for the Reception of Sounds in Water," by Mr. J. H. Powell; "A Direct-reading Frequency Meter of Long Range," by Mr. A. Campbell; a demonstration of the frequency meter will be given by Mr. W. H. Lawes, of the Cambridge Instrument Company. 5 p.m.

WEST BROMWICH ENGINEERING SOCIETY.—Technical School, West Bromwich. Paper, "Lighthouse Engineering: Marine Fog Signals," by Mr. W. F. A. Richey. 7.30 p.m.

SATURDAY, DECEMBER 13TH.

INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH, JUNIOR SECTION.—College of Technology, Manchester. Paper, "The Value of Technical Information in Foundry Work," by Mr. F. W. Rowe. 7 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Students' visit to the Research Laboratories of the General Electric Company, Limited, Wembley.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Newcastle-upon-Tyne. Papers: "The Choice of an Efficient Fan or Ventilator for a Mine," by Mr. Joseph Parker; "The Application of Air Screws to Mine Ventilation," by Mr. F. A. Steart; "An Experimental Study of Fan Evasées," by Professor Henry Briggs and Mr. James N. Williamson. 2.30 p.m.

MONDAY, DECEMBER 15TH.

BRADFORD ENGINEERING SOCIETY.—Technical College, Bradford. Lecture, "Water Purification, with special reference to Boiler Feed," by Mr. H. W. Coulson. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: SCOTTISH CENTRE.—Royal Technical College, Glasgow. Paper, "The Electric Road Vehicle," by Mr. D. E. Batty. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION.—Neville Hall, Newcastle-upon-Tyne. Paper, "Main Drainage of the Heaton and Walker Districts of Newcastle-upon-Tyne," by Mr. P. G. Pattison. 7.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Extra informal meeting to discuss the new Wiring Regulations of the Institution. 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, Westminster, London, S.W. 1. Graduates' Section meeting, "Some Aspects of Works Management, with a View to Cutting Costs of Production," by Mr. E. G. Davies. 7 p.m.

JUNIOR INSTITUTION OF ENGINEERS: NORTH-WESTERN SECTION.—Demonstration Hall of Pathé Frères, 15, Deansgate, Manchester. Lecture, illustrated by film, "Fire Fighting, Ancient and Modern," by Mr. G. E. Taylor. 7.15 p.m.

TUESDAY, DECEMBER 16TH.

ILLUMINATING ENGINEERING SOCIETY.—The Lighting Service Bureau, 15, Savoy-street, Strand, London, W.C. 2. Further particulars and demonstrations of recent advances in electric lamps and lighting appliances. 7 p.m.

INSTITUTE OF MARINE ENGINEERS.—85-94, The Minories, Tower-hill, London, E. 1. "Development of Steam and of Oil Engine Machinery for Propulsion," by Mr. E. G. Warne. 6.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: COVENTRY CENTRE.—Broadgate Café, Coventry. Paper, "The Maintenance of Commercial Vehicle Fleets," by Major E. G. Beaumont. 7.15 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, Westminster, London, S.W. 1. Paper, "Report on the Measurement of the Pressure of the Wind on Structures," by Dr. T. E. Stanton. 6 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Rankine Hall, Elmbank-crescent, Glasgow. Paper, "The Internal Combustion Locomotive," by Mr. James Dunlop. 7.30 p.m.

WEDNESDAY, DECEMBER 17TH.

ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN: BIRMINGHAM AREA.—Queen's College, Paradise-street, Birmingham. Lecture, "The Design of High-speed Alternating-current Generators," by Mr. W. Sharp. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Chamber of Commerce, New-street, Birmingham. Birmingham graduates' meeting. Paper, "Development and Possibilities of Multi-cylinder Two-stroke Engines," by Mr. R. W. Bent. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: WOLVERHAMPTON CENTRE.—The Engineers' Club, Queen-street, Wolverhampton. Paper, "The Tyre as Part of the Suspension System," by Mr. A. Healey. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, Westminster, London, S.W. 1. Students' meeting. Paper, "Mangahao Hydro-electric Power Station," by Mr. H. C. Reeves. 6 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Graduates' visit to Fry's Metal Foundry, Blackfriars, S.E.

NEWCOMEN SOCIETY.—Prince Henry's Room, 17, Fleet-street, London, E.C. 4. Paper, "The Development of the Cylinder Boring Machine," by Mr. E. A. Forward. 5.30 p.m.

ROYAL METEOROLOGICAL SOCIETY.—49, Cromwell-road, South Kensington, London, S.W. 7. Papers: "The Problem of Warm Polar Climates," by Mr. C. E. P. Brooks; and "Winds and Temperature in a Dry Atmosphere," by Sir Napier Shaw. 5 p.m.

RADIO SOCIETY OF GREAT BRITAIN.—Institution of Electrical Engineers, Savoy-place, London, W.C. 2. Annual general meeting. Lecture, "Photo-electrics," by Mr. C. F. Elwell. 6 p.m.

THURSDAY, DECEMBER 18TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Training School of Vauxhall Motors, Limited, Luton. Luton graduates' meeting. Paper, "The Principles of Economical Production," by Mr. E. Chatterton. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Chamber of Commerce, New-street, Birmingham. Paper, "Contract Arrangements for Laying Reinforced Concrete Foundations in Tilbury Housing Scheme," by Mr. A. Muir White. 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. "Speeding up the Telegraphs: A Forecast of the New Telegraphy," by Mr. Donald Murray. 6 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Connaught Rooms, Great Queen-street, London, W.C. 2. Institution dinner. 6.45 for 7.15 p.m.

FRIDAY, DECEMBER 19TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Watergate House, Adelphi, London, W.C. 2. London Graduates' meeting. Paper, "Tooth Gearing," by Mr. H. E. Merritt. 7.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—The Engineers' Club, Coventry-street, London, W. 1. Paper, "Locomotive Valves and Valve Gears," by Mr. J. W. Baldock. 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, Westminster, London, S.W. 1. Second Report of the Wire Ropes Research Committee. 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, Westminster, London, S.W. 1. Lecture, "Aircraft in Japan, Preceded by a Few Experiences of the King's Cup Race, 1924," by Colonel the Master of Sempill. 7.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Bolbec Hall, Newcastle-upon-Tyne. "Theory of Longitudinal Bending of Ships," by Mr. J. Lockwood Taylor. 7.30 p.m.

SATURDAY, DECEMBER 20TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—London Graduates' visit to the works of J. A. Prestwich and Co., Limited, Northumberland Park, Tottenham. 2.30 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Students' visit to the London Station of the British Broadcasting Company. 6.15 p.m.

TUESDAY, DECEMBER 23RD.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Society of Motor Manufacturers and Traders, 83, Pall Mall, London, S.W. 1. Informal meeting. Demonstration and discussion on "Anti-dazzle Devices." 6.30 p.m.

EXHIBITION OF SCIENTIFIC APPARATUS.—The annual exhibition of scientific apparatus organised by the Physical Society of London and the Optical Society is to be held on Wednesday and Thursday, January 7th and 8th, 1925, at the Imperial College of Science and Technology, Imperial Institute-road, South Kensington, and will be open in the afternoon (from 3 to 6 p.m.) and in the evening (from 7 to 10 p.m.). Mr. F. Twyman, F.R.S., will give a lecture on "Some Experiments with Interferometers" at 4 p.m. on January 7th and at 8 p.m. on January 8th. Mr. C. F. Elwell, B.A., M.I.E.E., will give a lecture on "Talking Motion Pictures" at 8 p.m. on January 7th and at 4 p.m. on January 8th. These lectures will include demonstrations.